United States Department of Agriculture

Office of the Chief Information Officer
Network Engineering Division

Geographic Network Analysis Process

Version 2.0

May 15, 1999

Prepared by
Pilot Research Associates, Inc.
1953 Gallows Rd. Suite 350
Vienna, VA 22182

Executive Summary

Scope of the Geographic Network Analysis Process

In response to ever-changing data network requirements, the USDA Network Engineering Division has developed a standardized process to network design that satisfies the connectivity needs of USDA business systems, processes, and users. The Geographic Network Analysis Process (GNAP) represents a sequence of activities that:

- analyze and define the current network operation
- translate new requirements into network specifications
- create appropriate network design modifications that satisfy performance, quality of service, and cost requirements
- test and evaluate new designs
- propose implementation guidelines

GNAP Operational Context – The USDA Information Technology Process

The GNAP is intended to complement the proposed USDA Information Technology (IT) Process—a generalized approach to translating mission program business needs into functioning applications. The proposed USDA IT Process (Fig. A) is cyclical and consists of nine phases:

- **Concept Phase** – interpretation of business application network needs into a high-level solution
- **Requirement Analysis Phase** – assessment of user needs and development of network requirements
- **Design Phase** – translation of network requirements into system specifications
- **Application development Phase** – development of a complete information system from system specifications
- **Testing/Validation Phase** – verification of system specifications
- **Installation Phase** – implementation of the information system in a production environment
- **Operation Phase** – initiation of routine information system operation
- **Maintenance Phase** – maintenance of routine information system operation
- **Retirement Phase** – termination of information system in an orderly fashion

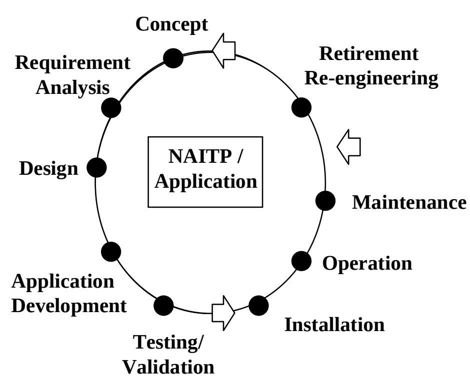

Figure A USDA IT Process

Operational Relationship between the IT Process and GNAP

The Network Application Identification and Tracking Process (NAITP), which monitors the readiness of the enterprise network to support new or enhanced applications, provides the signal to initiate the GNAP (Fig. B).

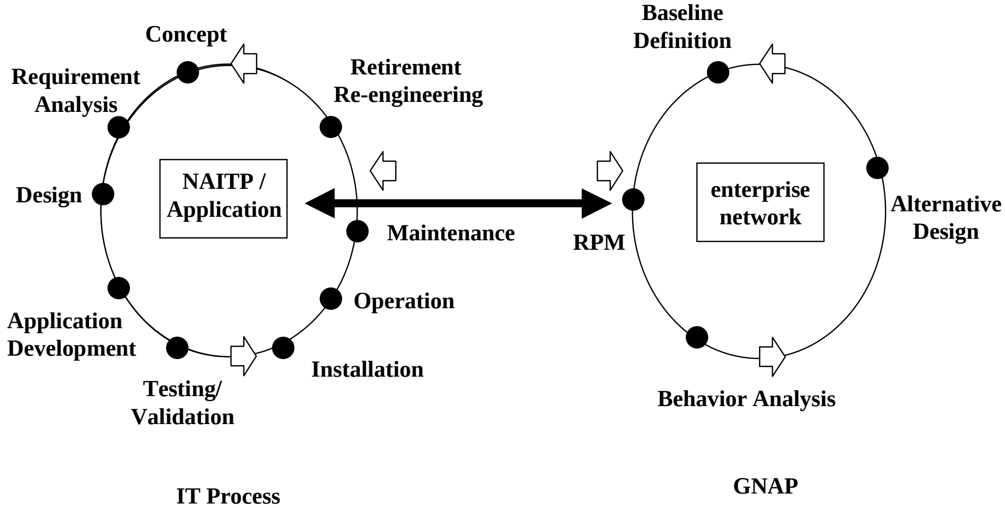

Figure B Relationship Between the IT Process and GNAP

Geographic Network Analysis Process

The GNAP is focused on supporting USDA expansion and change activities—new applications, modifications to existing applications, and changes to the network infrastructure. The result of the GNAP is a design describing network topology and link characteristics that meet application needs. There are four procedural elements to the cyclical GNAP (Fig. C).

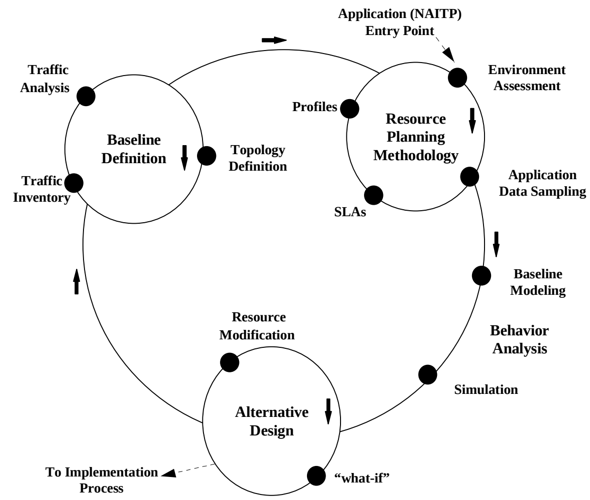

Figure C Geographic Network Analysis Process

Baseline Definition Process - The Baseline Definition Process establishes an accurate description of the existing network and provides the foundation for future planning activities by documenting network:

- topology
- infrastructure
- traffic activity

Resource Planning Methodology - In order to plan resources required for new and existing applications or infrastructure changes independent of applications, it is necessary to measure application demands on the network. The Resource Planning Methodology includes procedures for:

- environment assessment
- application data sampling
- service level agreement generation
- application profile generation

Behavior Analysis Process -The Behavior Analysis Process assesses the application profile prediction of network performance. This Process can be initiated by the Application Development Process or the routing enterprise network change process. The current network Baseline Model is analyzed to provide a quantitative assessment of network performance. The Behavior Analysis Process functions by creation of a Baseline Model to Simulate the application profile requirements.

Alternative Network Design Process -The Network Design Process proposes alternative network configurations based on the results of the Behavior Analysis. The new Baseline Model represents the design starting point where network resources are modified and simulations are conducted until the quality of service specifications established in the Resource Planning Methodology are met.

The result of the Design Process represents guideline for implementation of the necessary network changes. The actual implementation is within the purview of the Network Operations Center.

Network Analysis Tools

The GNAP is a sophisticated analysis process that is further complicated by the complexity of modern data networks. Data collection, analysis, and performance management tools are essential to developing network design alternatives that satisfy the growing demands of business applications and sophisticated users. To ensure the best results, it is mandatory that network analysis engineers conduct surveys of available tools and evaluate their performance.

TABLE OF CONTENTS

TABLE OF FIGURES

LIST OF TABLES

1.0 Introduction

Driven by new and rapidly changing requirements placed on the USDA data networks, the USDA Network Engineering Division (NED) must adopt a process-oriented approach to network design. That is, a continuous method to change the networks to accommodate new requirements and technologies.

The Geographic Network Analysis Process (GNAP) version 2.0 describes a set of iterative processes that create network design alternatives. These alternatives represent the best solution to criteria and objectives established for particular requirements; for example, the alternative that meets certain performance objectives while minimizing cost.

1.1 Background

The Office of the Chief Information Officer (OCIO) Strategic Plan identified the need to develop Department-wide information technology infrastructures to improve services delivery using more effective information systems and data management. This strategic requirement was translated into the development of the Telecommunications Enterprise Network (TEN). The NED imposed order to the development of the TEN by creating a standardized assessment and recommendation procedure.

The GNAP will assist in the achievement of the *USDA Telecommunications Architecture* [1] and thus the objectives of the 1993 Government Performance and Results Act and the implementation of the 1996 Information Technology Management Reform Act. The *Telecommunications Architecture* is USDA's framework for managing the efficient use and continued evolution of telecommunications services and systems in performing the Department's mission. The GNAP will advance consistent design of Agency work processes and will enable information exchange among the automated systems that support these processes.

GNAP Version 1.1 [2] (Figure 1) has been used for feasibility studies and demonstrates the value of a standard approach for analyzing all needs and requirements of USDA organizations.

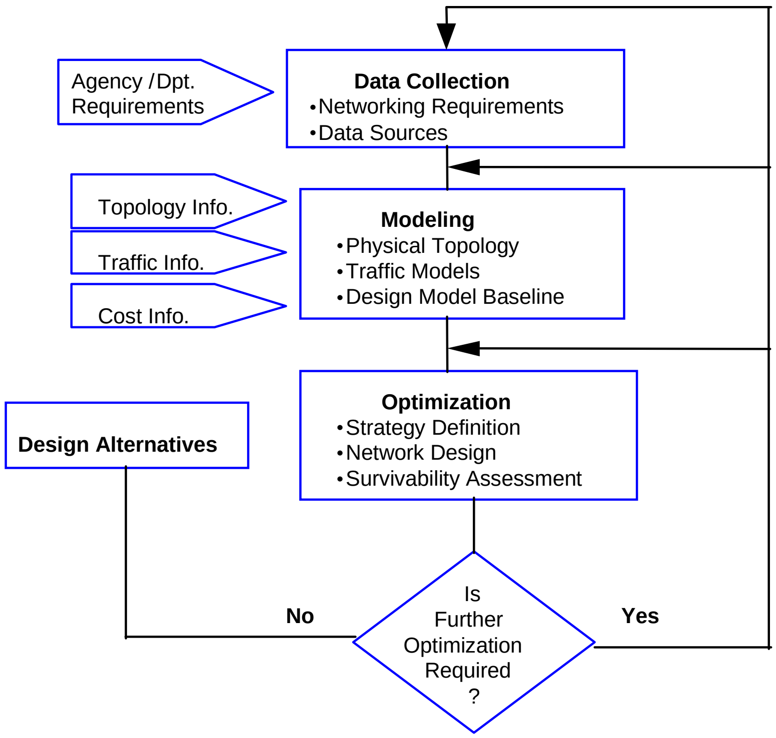

Figure 1 GNAP Version 1.1 Model

1.2 Objectives of the GNAP Version 2.0

The objective of the GNAP is to provide a set of guidelines and procedures for the design of the USDA enterprise network that will satisfy the connectivity needs of USDA systems, processes and users. The GNAP provides a standardized, reproducible process while remaining flexible and general enough to evolve with the best practices established by USDA.

The GNAP focuses on setting objectives, determining data to collect, making deployment assumptions for new applications, and assessing enhancements to existing applications. The process predicts the effects of such changes (for example, network performance and relative cost) under conditions that may not yet exist in reality.

GNAP provides the guidelines necessary to modify the enterprise network infrastructure that adequately support the functionality to satisfy the USDA mission requirements in terms of performance, Quality of Service [QoS], and cost.

1.3 Characteristics

The GNAP is an integral part of the USDA Information Technology (IT) process. At the time of this writing the USDA IT process is not completely defined. A brief overview of the USDA IT process model is presented in Section 2.2 - GNAP Context.

The GNAP provides a roadmap for developing a technically sound and economical telecommunications network design. The process is intended to guide and document the development of network designs; emphasizing the detection of network flaws as well as possible improvements.

The main characteristic of the GNAP is the cyclical nature of the entire process as well as each of its components. Activities within the process are repeated periodically (synchronously or asynchronously) to update the enterprise network information and to identify and characterize the changes that occur over time.

1.4 Document Organization

The GNAP version 2.0 introduction is followed by a Process overview (Section 2.) as it relates to the USDA Information Technology process.

Section 3 addresses the invocation of the Process and the interrelationship of its elements. Sections 4 through 7 describe details of the GNAP elements - Baseline Definition Process, Section 4; Resource Planning Methodology, Section 5; Behavior Analysis, Section 6; Alternative Design process, Section 7. Section 8 is a list of acronyms while Section 9 provides Works Cited.

2.0 General

2.1 Definition of Terms

The definitions below provide clarification of expressions used in the context of GNAP.

Application—The generic definition of an application is the action taken within a data processing system to provide a service to the user. Example of existing USDA applications are PC-TRAV (employee travel processing), PC-TARE (employee time and attendance filing application), and CAMS (combined administrative management). Within the context of GNAP, application is the fruit of an IT process cycle (see Figure 2 - USDA IT Process Model).

Application-based traffic—Application-based traffic or Application-based data is application specific traffic (for example, HTTP and TCP). This traffic is usually measured using traffic analyzer probes. This type of data is considered en-to-end traffic while Usage-based traffic is considered network node-to-node (for example, router-to-router).

Application Profile—Application profile is the representative model of the traffic characteristics of a set of application transactions based on the data sampled with traffic analyzer probes. Existing application traffic profiles are maintained in the application database.

Background noise - The background noise (background traffic), in the GNAP context, is application-based traffic models for current applications that are already part of the current network baseline model.

Conversation - A conversation is the bi-directional exchange of packets between two hosts (for example, client/server).

Enterprise Network - GNAP is a generic process and is capable of addressing all USDA network design needs. The enterprise network defined here has no particular size and complexity associated with it. The enterprise network may be a particular USDA agency network, or the combination of several or all USDA networks, or even portion of a network.

Enterprise Network Management - In GNAP, the enterprise network is generic (see definition above). It is assumed that there is an enterprise network management entity, called Network Operation Center (NOC) associated with the enterprise network. This function can be localized or distributed. This entity addresses the five major network management disciplines: fault management, configuration management, performance management, accounting management and security management.

GNAP Cycle - A GNAP cycle is one instance of GNAP execution from start to end. The GNAP objectives dictate the actual elements that will be executed in the cycle. Not all GNAP cycles execute every element.

GNAP Objective - The GNAP objectives are the requirement and purpose which initiate the current GNAP cycle. GNAP is cyclical in nature. In an overall project GNAP can be re-enter many times. The objectives can be the same or different each time the cycle is entered.

Live / Real network - Live network is used to differentiate between the network model used during development (for example, Baseline Model) and the real network being the actual implemented and functional enterprise network.

Network Operation Center (NOC) - See Enterprise Network Management.

New Baseline - The new baseline identified is the baseline being used in the Behavior Analysis and Alternative Development processes. The current and/or updated baseline is the enterprise network baseline model that has been created in the Baseline Definition Process. The new baseline is the baseline model made of two components:

- The current baseline or portion thereof; **and**
- The network changes identified as the results of the Resource Planning Process (RPM) relative to the GNAP objectives.

Quality-of -Service (QoS) - Quality-of-Service have different attributes based on the service provided. In GNAP, the enterprise network provides telecommunications service to new or existing applications. Therefore, in this document, QoS are associated with network service. QoS attributes address mainly delay (response time) and available bandwidth.

Service Level Agreement (SLA) - In the generic sense, SLA defines the responsibilities of both the service provider and the user of those services. In this document, the service is the telecommunications services provided by the enterprise network. The SLA is divided into two components: a) administrative agreement (for example, service operating schedule), b) service performance attributes. GNAP addresses only performance attributes.

Usage-based Traffic - Usage-based traffic or Usage-based traffic data is the total aggregate traffic observed on a link (for example, WAN link). No particular application traffic can be distinguished from usage-based traffic.

Usage-based traffic can usually be extracted from network node statistic data storage.

Transaction - An application transaction is part of a conversation associated with initiation, termination, or data transfer for an application. An example of a transaction is a login procedure; the transaction includes all the data transfer related to that procedure.

2.2 The GNAP Context

The GNAP is an integral part of the USDA IT Process. Although currently under development, the IT Process is expected to be similar to the model presented in Figure 2. Regardless of the continued development, the IT Process model provides a context for discussion of the GNAP.

To be accomplished, an IT project often involves new or modified computer technology (hardware, software or both), special technical skills (systems analysis, computer programming) or expertise with telecommunications or other equipment. Furthermore, USDA IT projects vary greatly in size, scope of application, processing complexity as well as the technologies and methodologies used. Despite the enormity of possible requirements and specifications, IT projects all follow the same basic life cycle.

The Information Technology Project Planning Process provides a mechanism to accomplish USDA mission-critical activities and to meet Program Unit performance goals using technology compliant with current Departmental requirements.

2.2.1 USDA Information Technology Process Model

As described in this section, the USDA IT Process is hypothetical. However, the actual process to be used by the USDA, the subject of another document, is expected to be similar to this model. When the USDA adopts a final process, the present document will be updated accordingly.

The IT Process begins with an Agency or Department level business requirement (Fig. 2). The requirement may be based on USDA program needs, overall IT strategy, Departmental guidance, external customer request, legislation, or other Federal mandates.

The USDA IT Process model has nine phases:

- Concept Phase
- Requirements Analysis Phase
- Design Phase
- Application Development Phase
- Testing / Validation Phase

- Installation Phase
- Operation Phase
- Maintenance Phase
- Retirement or Re-engineering Phase

The USDA IT Process is cyclical beginning with the Concept phase and ending with the Retirement or Re-engineering phase. It is important to remember that during the life cycle of a project, elements of the IT Process may be accessed many times. Furthermore, it is assumed that the USDA Network Application Identification Tracking Process (NAITP) will be initiated within the IT Process life cycle. As required, the GNAP may be initiated from any phase of the IT Process.

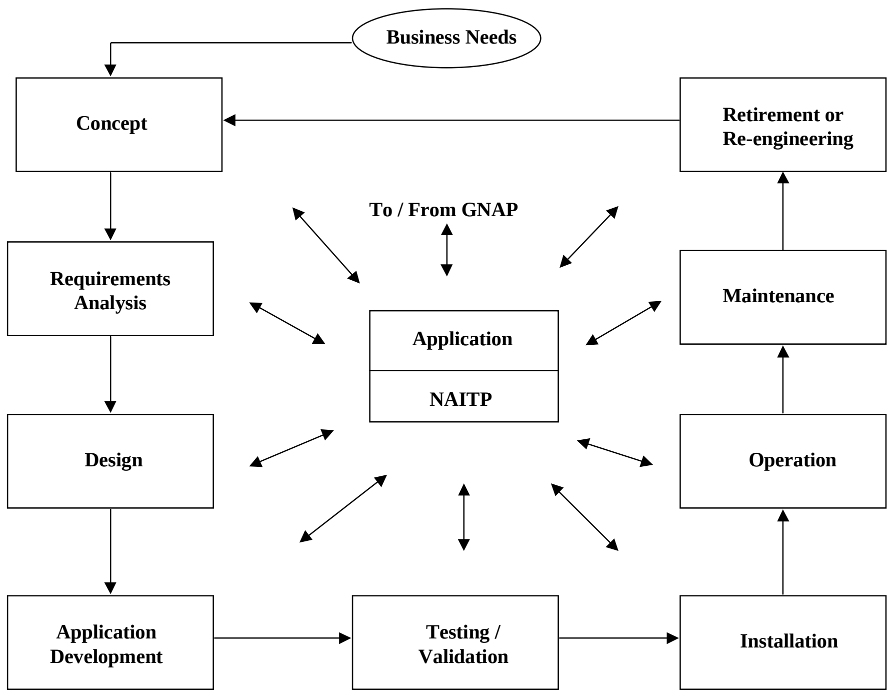

Figure 2 USDA IT Process Model

2.2.1.1 Concept Phase

The Concept Phase interprets the broad network needs of the business application and outlines a high level solution. This high-level project definition is used to justify the acquisition of resources required for the subsequent phases of the IT Process.

2.2.1.2 Requirement Analysis Phase

The Requirement Analysis Phase assesses user needs and develops appropriate requirements. User requirements are defined at a level of detail sufficient to permit system design to proceed. These requirements provide the basis for a more concrete assessment of system benefits and costs as well as the detailed design of the system.

2.2.1.3 Design Phase

The Design Phase transforms the detailed requirements definition into complete system specifications. While remaining sensitive to the original business initiative, the analyses of this phase convert the functional and data requirements into a complete system design.

2.2.1.4 Application Development Phase

The Application Development Phase converts the Design Phase system specifications into a complete information system. Although activity in the Application Development Phase addresses the system resident software, this phase also puts in place the hardware, the communications environment, and the other important elements of the overall system.

2.2.1.5 Testing / Validation Phase

The primary purpose of this Phase is to prove that the developed system satisfies the requirements defined in the functional requirements.

2.2.1.6 Installation Phase

The Installation includes efforts required to prepare for implementation of the new system, to implement the system in a production environment, and to resolve problems identified during the implementation process.

2.2.1.7 Operation Phase

In this phase the system is fully operational. It is essential that users are aware of their operational roles and responsibilities. Providing user support is an ongoing activity; it includes training for new users and assistance to new and existing users.

2.2.1.8 Maintenance Phase

Maintenance activities for the system to ensure that any previously undetected errors are fixed. Maintenance includes implementation of hardware updates, new releases of system software, and application software packages used to operate the system. Maintenance also includes routine system monitoring to identify potential modifications needed to ensure reliable, high quality data transfer.

2.2.1.9 Retirement or Re-engineering Phase

Retirement activities ensure the orderly termination of the system and the proper documentation of vital information about the system so that some or all of it may be reactivated. Particular emphasis is given to proper preservation of the data processed by the system so that re-engineering may be possible.

2.2.1.10 NAITP/Applications Phase

The Network Application Identification and Tracking Process (NAITP) ensures the readiness of the enterprise network to support new, enhanced, and existing network applications. The NAITP uses known sources of system planning information, known application developers and serendipity to identify applications potentially impacting network resources.

At the highest level, an application is defined as the action taken within a data processing system. Examples of existing USDA applications are:

- PC-TRAV - Employee travel processing
- PC-TARE - Employee time and attendance filing application
- DLOS - Rural Development Loan/ Credit/ Debt processing and tracking

2.2.2 IT Process/GNAP Relationship

The NAITP and Application Development Process are considered part of the IT process. When the NAITP indicates that an application requires enterprise network services, the GNAP is initiated. The Application Development Process should include links to the GNAP. NAITP is the link between the IT process and the GNAP for applications requiring the enterprise network services.

Both processes are recursive. The GNAP may be accessed at any point in the IT Process and may be re-entered as many times as required.

The GNAP is also recursive and may return to the IT process as many times as required.

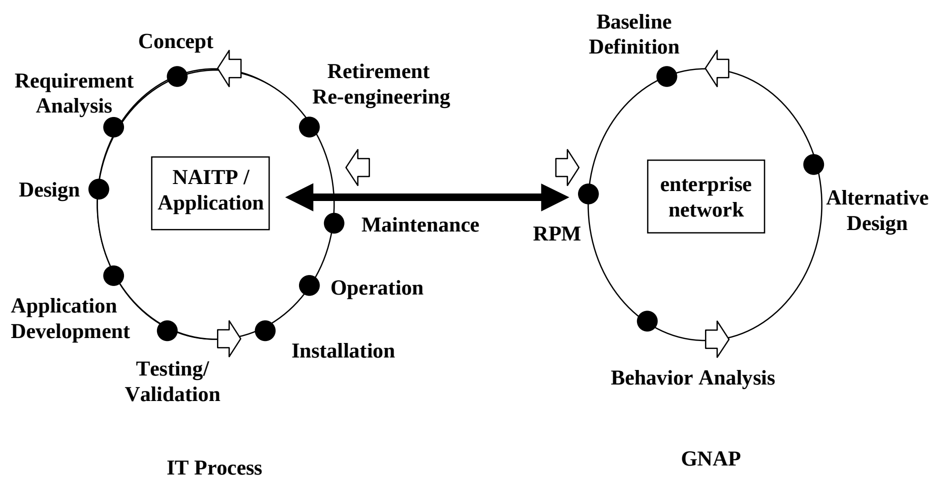

Figure 3 IT Process/GNAP Relationship

2.3 Overview of GNAP Version 2.0

The GNAP is the USDA standard network analysis process for designing and modifying the USDA Enterprise Network, and portions thereof, during all phases of the USDA Architecture implementation. Its main objective is to provide a repeatable process for network design that satisfies the connectivity needs of USDA business systems, processes and users.

The GNAP focuses on supporting USDA network expansion and change activities. It includes telecommunications needs of new applications, modifications to existing applications, or changes in the infrastructure of the enterprise network. The output of the GNAP is an alternative design describing network topology and link characteristics necessary to satisfy application requirements. Details of the GNAP are found in Sections 3 through 7.

The cyclical nature and unique interaction of GNAP component procedures characterize the process. However, before discussing GNAP interactions (Section 3.0), it is important to understand each of the component procedures.

2.3.1 GNAP 2.0 Scope

There are two primary high level events that initiate the GNAP 2.0:

- The GNAP is initiated by application support and development within the Network Application Identification Tracking Process (NAITP) [3]. Process initiation requires input of unique application

characteristics such as Quality of Service (QoS) goals, deployment requirements, and performance requirements associated with the application. GNAP output is the definition of the network (within the enterprise network) supporting the application and high-level network design alternatives that are forwarded to the enterprise network implementation process.
- Changes in the enterprise network attributes associated with its management process may invoke one or more GNAP cycles. It is conceivable that characteristics such as network congestion, change of services from carriers, and/or tariffs may trigger the GNAP at different points in the process.

The following events are examples of GNAP initiation by the enterprise network management:

- trouble ticket processing
- observation/suggestion by the NOC team
- NOC network inventory update
- circuit utilization
- application implementation on production network

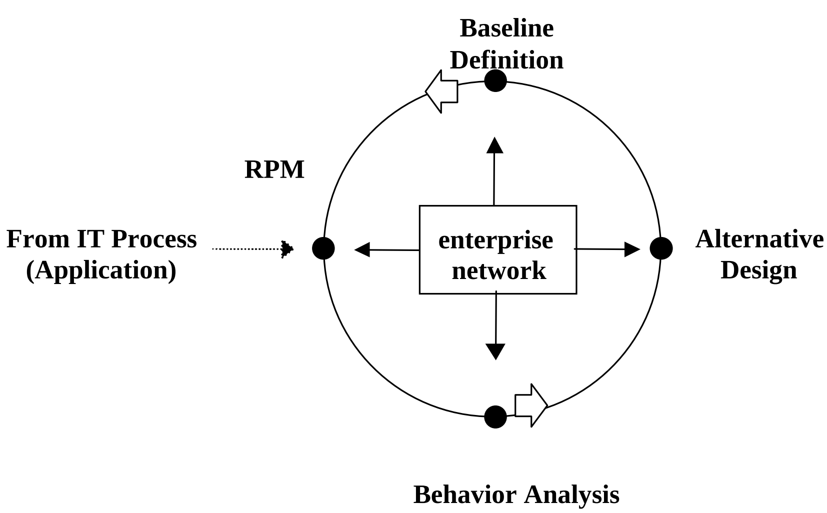

Figure 4 General GNAP Model

There are four distinct elements of the GNAP. These elements are based, in part, on the Network Resource Planning process [4] and are tailored specifically for the USDA environment. The elements are:

- Baseline Definition Process
- Resource Planning Methodology (RPM)
- Behavior Analysis
- Alternative Network Development

2.3.2 GNAP 2.0 Elements

The four elements of the GNAP are distinct processes as described in this section.

2.3.2.1 Baseline Definition Process

The Baseline Definition Process establishes an accurate understanding of an existing network. It is a process that documents the equipment and usage of the network being studied. Major results of this process are:

- description of network topology
- characterization of the network infrastructure
- definition of network activity in terms of traffic flows

The Baseline Definition Process provides the foundation from which all further planning activities can be undertaken (for example, new applications, consolidation of existing services, expansion of the network, performance improvements, etc.).

There are three steps (or sub-processes) associated with the Baseline Definition Process:

Topology Definition: The topology definition includes a) the *network inventory* consisting of the recording of the network nodes and associated characteristics as well as routers, switches, Local Area Networks (LAN), LAN links and Wide Area Network (WAN) links; b) the *topology* of the network consisting of the physical and logical relationship of Baseline network elements; c) the *validation* of the information obtained from multiple sources such as discovery Network Management System (NMS) and other sources.

Traffic Inventory: Traffic inventory is a record of the traffic flowing across the baseline network. The inventory includes usage-based traffic and application-based traffic.

Traffic analysis: Usage-based traffic recorded in the traffic inventory is analyzed to determine the baseline network utilization and available capacity. Application-based traffic is also analyzed to define the major applications transiting the network and to describe their network resource usage.

2.3.2.2 Resource Planning Methodology

Resource Planning Methodology (RPM) encompasses resource planning activities that characterize demands of USDA applications on a network. There are two major network design activities requiring the RPM process:

- network changes associated with new and existing applications
- network infrastructure changes independent of applications

Resources can be planned based on the introduction of new applications or assessment and modification of current applications. RPM requires that application transactions be measured to determine the demand that applications make on the network. The resultant application profiles and the modeled baseline can be superimposed to simulate load on the network. The newly created profiles and associated application information are added to the existing USDA Application Database. This database is used to keep an inventory of all of the Applications, and their respective profiles, currently running over the USDA data networks.

In addition, Service Level Agreements (SLA) are generated in this phase of the process. SLA's specify the target levels of service quality required by the enterprise network to support the specific application. The SLA is forwarded to the Application Development Process. The SLA describes a contract between the Application Development Group and the service provider (enterprise network) in terms that are meaningful to the application development process.

Resources can also be planned to modify the enterprise network infrastructure independently of the applications (for example, change of network node location). In this case the application load on the enterprise network remains constant, only the physical/logical infrastructure changes.

There are four sub-processes within RPM:

Environment Assessment – This sub-process uses actual network change requirements to assess the network environment. In addition, application and infrastructure deployment plans are assessed, application transactions are identified, and the quality of service (QoS) and design criteria are established.

Application Data Sampling - Regardless of the reason for initiating RPM, traffic data is an element of network loading and is therefore required to assess network changes. If initiated by independent network changes, RPM requires only baseline traffic for modeling the changes.

For application planning, transaction samples are obtained by running the application in a controlled environment (laboratory or on the actual enterprise network / portion thereof). Using a traffic analyzer, data corresponding to an application's transactions is captured. QoS is established in this phase of the process.

SLA Generation - From the QoS established in the Application Data Sampling Process, the enterprise network (supporting the application) SLA is generated. Attributes covered by the SLA include utilization, transaction processing rates, and delays.

Profile Generation - This sub-process creates traffic models (profiles) reflecting individual transactions determined during the Application Data Sampling sub-process. An application transaction is the elementary building block of a profile. When combined, multiple application transactions are used to model entities such as user profiles that represent the typical load of an individual application.

2.3.2.3 Behavior Analysis Process

The Behavior Analysis Process allows assessment of the network behavior prediction. Two major events can initiate this process:

- the Application Development Process
- the associated enterprise network change process

In both cases, this phase employs the most current enterprise network baseline model or a representative part of the baseline. Analysis on the entire baseline quantifies the assessment of network performance and survivability. The assessment may be viewed as an independent product of the behavior analysis phase and/or as input data for the next GNAP phase Alternative(s) Network Development.

Behavior Analysis is composed of two sub-processes.

Baseline Model – For practical reasons, the analysis is generally run on a representative part of the enterprise baseline model. Simulation on the entire enterprise baseline model is inordinately clumsy, complicated, and time-consuming. This new baseline model is made of three distinct layers:

- physical topology as determined by the baseline model
- existing application traffic
- application specific profiles created in the RPM process

Simulation - The simulation run on the newly created baseline provides performance and survivability attributes as well as documenting network resources that may prevent attainment of acceptable criteria.

2.3.2.4 Alternative Network Design Process

The Network Design Process proposes alternative network configurations based on the results of Behavior Analysis. The previous phase establishes a new baseline from which a new design process starts. The network design process is iterative; modifying the modeled network resources (WAN circuits) and running simulations until the QoS established in the RPM process is met.

Depending on current network design requirements, one or more of the following attributes may be addressed in the proposed network alternative(s):

- physical configuration of the network
- topology characteristics (backbone, access areas)
- monthly recurring charge
- performance characteristics (propagation delays, number of hops)
- survivability assessment

The result of the Alternative Network Design Process remains at a high level in the Network Design implementation hierarchy. Only the guidelines and high-level network design attributes continue to the Implementation phase. The Implementation Phase, usually performed by the enterprise network Operation Center (NOC), is outside the scope of the GNAP.

2.3.3 Enterprise Network

The enterprise network provides the telecommunications services required by the new or modified applications.

To keep the Process general, there is no particular network defined in the model. The enterprise network may be viewed as the Telecommunications Enterprise Network (TEN) currently being considered by USDA. It could also be defined as the current combined USDA networks, or even a portion of it.

The enterprise network entity within the GNAP Model encompasses,

- Network infrastructure topology (nodes and links)
- Current traffic (load and type)

2.3.4 Network Tools

Implementing the GNAP usually requires network tools. Data collection, analysis, and performance management tools are needed to accommodate the enterprise network design. These tools are used in all elements of GNAP.

An important prerequisite for implementing the GNAP is the definition of the appropriate set of tools. All tools have limits as they are invested with implicit methodology and a set of characterizations and constraints.

Data collection and analysis tools are very important for collecting *live* data from the enterprise network and controlled environment for use in performance management tools.

The data collection and analysis tool are divided into two major categories:

- Router Management Information Base (MIB) statistical collection tools
- Traffic analyzers and Remote Monitoring (RMON)-compatible network probes

Performance management tools are involved in the measurement and prediction of the enterprise network performance. Performance attributes includes throughput, link utilization, error rates, and response time.

3.0 Interactions of GNAP Elements

The GNAP is characterized by its cyclical nature and interaction of its component procedures. This section of the document highlights the cyclical characteristics of the entire process, as well as the cyclical nature of the individual elements making up the process. In addition, the relationships and interaction among the different GNAP procedures is addressed.

3.1 General

The USDA IT process is itself recursive (Section 2.2.1). During the life cycle of an IT project, elements of the process can be accessed many times. Since the GNAP is an integral part of this process, it also is recursive.

By definition, the main objective of the GNAP is to provide a repeatable network design process that satisfies the connectivity needs of USDA systems, processes, and users. Several triggering events—such as new application requirements, changes in the enterprise network attributes, or periodic network updates that identify and characterize ongoing changes—can invoke the process cycle.

Once the GNAP has been invoked by a triggering event, the process, or portion thereof may be accessed multiple times. Such a case would be a requirement for an incremental refinement of the design. For example, in an IT process requiring the deployment of an application, a rough cost estimate may be required. The GNAP is then invoked to create a rough network design for cost analysis purposes.

The GNAP is designed to remain flexible and sufficiently general to evolve with the best practices established in the USDA. To satisfy this requirement there are no concrete rules defining the GNAP entry points or which elements must be executed. However, there are certain sequences of events that must be respected to realize maximum benefit from the GNAP. The interdependence of the GNAP elements is addressed in the remainder of this section.

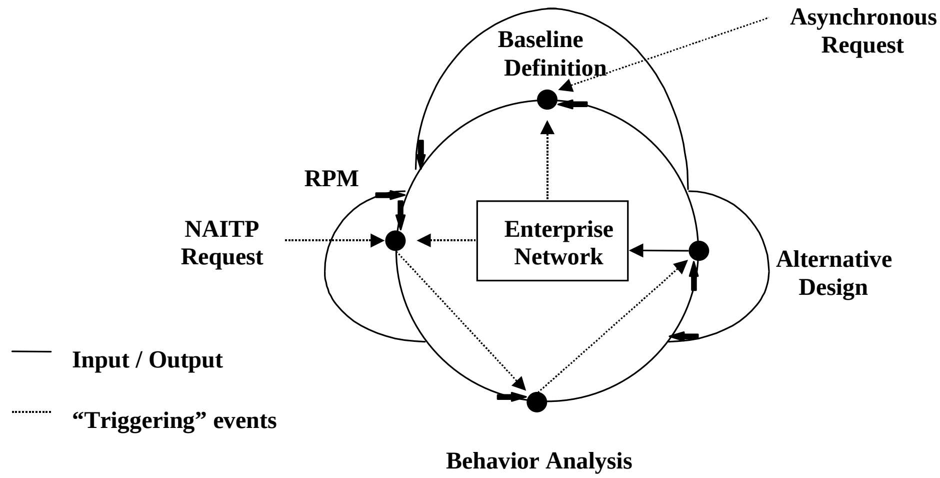

Figure 5 Interdependence of the GNAP Elements

Figure 5 shows the interaction among GNAP elements. It shows the major iterative paths in the process as well as the anticipated entry points. The elements of the GNAP are placed in logical order of execution (see arrows) in the model.

To provide the required process flexibility, it should be understood that in some applications of the GNAP a particular element or sub-element might be null. That is, the process may not require all elements or sub-elements to be executed. A null element is bypassed without action.

3.2 Baseline Definition Element

The Baseline Definition Process establishes an accurate understanding of an existing network. The process documents the equipment and usage of the network being assessed. This element is made of three sub-elements:

- Topology Definition
- Traffic Inventory
- Traffic Analysis

The Baseline is the initial model of the enterprise network being considered. It describes, with reasonable accuracy, the network components and traffic supporting the current applications.

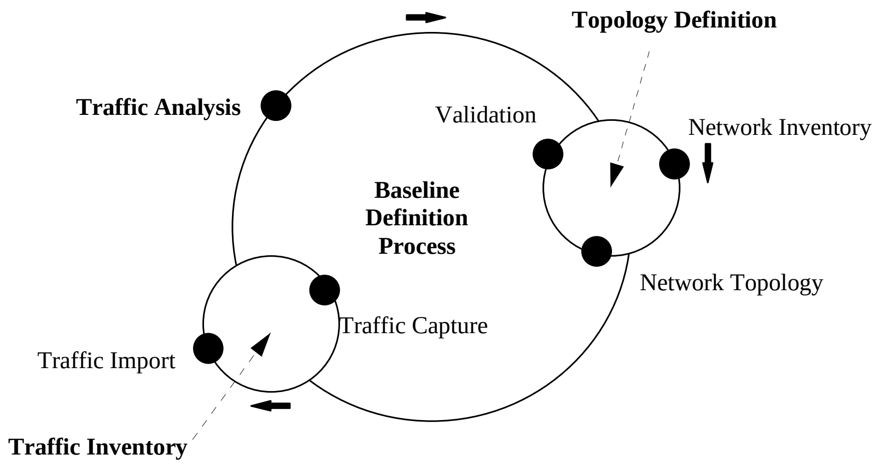

Figure 6 Baseline Definition Process Model

3.2.1 Cyclical Characteristic

Because an enterprise network is dynamic, the Baseline Model needs to be updated periodically to reflect changes—the Baseline Definition Process must be repeatable.

The Baseline Definition Process can operate independently of the basic GNAP and, as such, is used by the other elements as a resource. There are cases when the Baseline Definition Element is invoked asynchronously by the Application Development Process (for example, when the baseline is too old). The enterprise network's NOC may also asynchronously invoke the Baseline Definition Element when significant changes are made to the network.

However, as a general rule, the baseline process should be invoked synchronously (independent of application and NOC needs) at regular intervals. Resources available to perform the task, as well as the size of the enterprise network, dictate the synchronous frequency of the Baseline Definition Process.

It is very important that the Baseline Definition Process components be executed in quasi-simultaneous fashion. That is, all the sub-elements of the baseline process should be executed in a timely manner relative to each other. Using unnecessarily long or random time intervals between the execution of sub-elements may cause building a baseline model with aged information.

3.2.2 Relationship to Other Elements

Since all other components in the GNAP use it as a resource, the Baseline is considered to be the first element. As the first GNAP element, the Baseline Model must be validated if reliable information is to result.

The Baseline of the enterprise network can be used by itself for analysis of network utilization and to document the network. The Baseline steps required for a particular analysis depend of the objective for initiating the GNAP. For example, the current GNAP objective may be limited to maintaining the topological inventory of the enterprise network.

The output of the Baseline is used by the next logical GNAP element—Resource Planning Methodology—as the basis for application or capacity planning.

3.3 Resource Planning Methodology Element

The Resource Planning Methodology (RPM) characterizes enterprise network application demands. There are two major activities initiating the RPM process:

- network changes associated with applications (new and existing) invoked by the NAITP
- network infrastructure changes independent of the applications

There are four sub-processes included in the RPM:

- Environment Assessment
- Application Data Sampling
- Service Level Agreement Generation
- Profile Generation

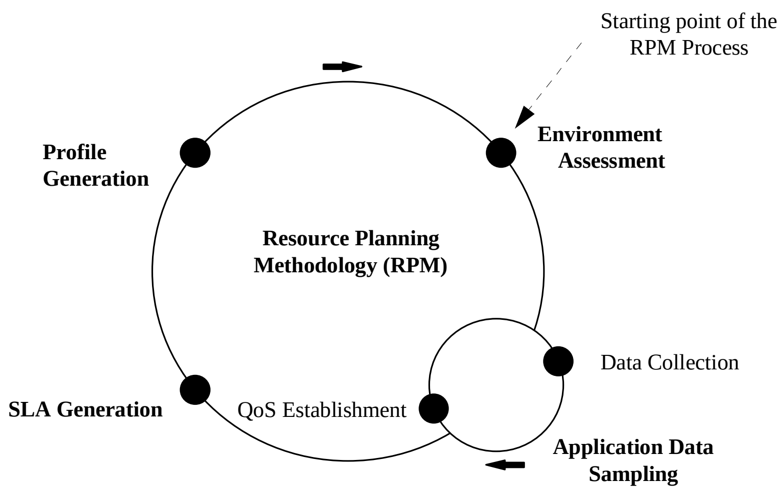

Figure 7 RPM Model

3.3.1 Cyclical Characteristic

As with the Baseline Definition Process, the RPM processes are also cyclical. They may need to be repeated to refine the information or to reflect changes in the network environment or applications.

To generate traffic profiles representing applications, a set of transactions related to the appropriate application must be captured. Whether the data capture is manual or automatic, the application data sampling is a repetitive process.

3.3.2 Relationship to Other Elements

As mentioned before, the RPM relies on the availability of the latest complete enterprise network baseline model (see Section 3.2).

The Environment Assessment is always executed. The execution detail is dependent on the current GNAP objectives—reason for which GNAP is invoked (for example, NAITP or enterprise network NOC initiated).

RPM results may well be of independent interest (for example, SLA’s). But the main value of RPM is providing input to the Behavior Analysis and the Alternative Design processes. The application profiles created and the information obtained is used for doing what-if modeling and analysis.

The source of information and method of executing the Application Data Sampling may differ from one GNAP objectives to another. However, in all cases identified so far, the Application Data Sampling phase is required.

The SLA generation is only applicable when GNAP is invoked by NAITP relative to new or existing applications. It is assumed that when GNAP is invoked because of an enterprise network topology change, the SLA’s are already in place.

The Profile Generation Element is usually executed when the RPM addresses new applications. This sub-process may also be used to address existing applications that are included in the Application Database. The profile of applications affected by the change is assumed to exist in the Application Database.

3.4 Behavior Analysis Element

The Behavior Analysis Element assesses the network infrastructure supporting the changes made to the network. The assessment primarily addresses performance and survivability characteristics. The network changes can be initiated by:

- The application development process (NAITP); or
- The enterprise network management process

Behavior Analysis creates a unique network baseline process reflecting required network changes. The traffic information including the existing related application traffic and traffic profiles generated in RPM are used in the behavior analysis process.

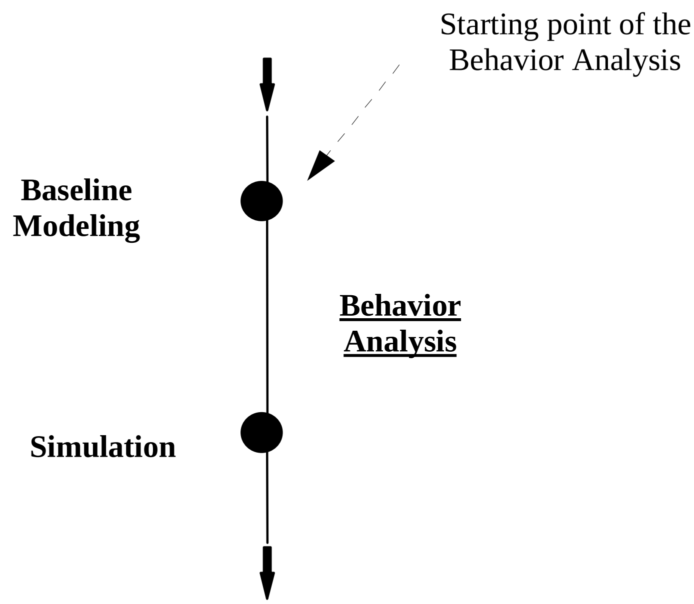

Figure 8 Behavior Analysis Model

3.4.1 Linear Characteristic

Behavior Analysis prepares a new, exclusive Baseline model compliant with the GNAP objectives. Therefore the process is linear and has no cyclical characteristic.

3.4.2 Relationship to Other Elements

The Behavior Analysis Element uses the most current enterprise network baseline model or a representative part of the baseline to create the appropriate topology of the new baseline.

Background application traffic related to the new baseline is obtained from the Application Database. The application traffic profiles, associated with the analysis, are the results of the RPM process.

Note: The Behavior Analysis process may involve the entire enterprise network. In this case, the current enterprise network baseline, including topology and traffic, is used in the analysis.

The resulting baseline model created for the Behavior Analysis and the performance and survivability attributes are used as the starting point for the Alternative Network Development Element (next GNAP sub-process).

3.5 Alternative Network Development Element

This element of the GNAP proposes alternative network configurations that satisfy the GNAP strategy requirement and reflect the new baseline established in the Behavior Analysis Element. If the new baseline was created from a portion of the enterprise network baseline (see Section 3.2), it is inserted back into the enterprise network baseline. What-if scenarios are executed in an iterative manner until the QoS established in RPM is met.

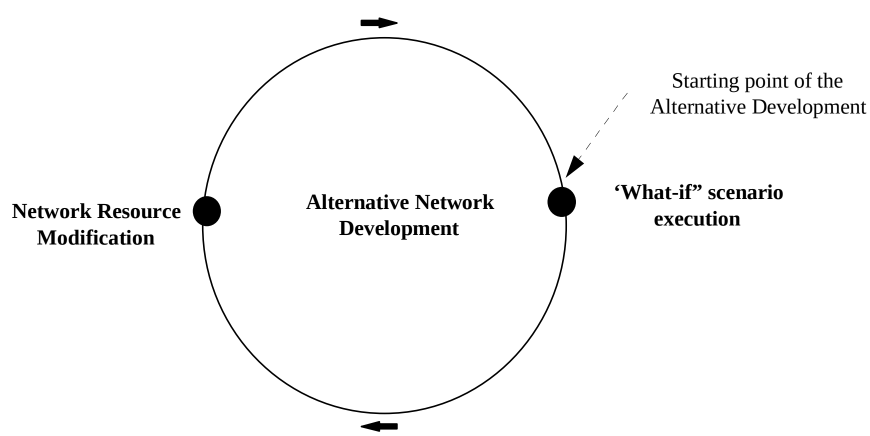

Figure 9 Alternative Network Development Model

3.5.1 Cyclical Characteristic

The Alternative Network Development process is cyclical. It consists of modifying the modeled network resources within the entire enterprise network context. The modification process is repeated as many time as necessary to meet the application requirements and the QoS.

3.5.2 Relationship to Other Elements

The Alternative Network Design Element is the natural end of one complete GNAP cycle.

This element, which has various degrees of dependency on the other GNAP element, is related to the GNAP objectives. The GNAP objective can vary from a simple partial network inventory to a complete redesign of the enterprise network.

3.6 Scenario Examples

The scenarios proposed below are presented to show the relationship between the GNAP elements. The examples are generic and presented at a very high level to maintain the idea of flexibility of the process. GNAP is designed to fit all the USDA network design needs.

The scenarios identified for this exercise are:

- A GNAP initiated by the identification of an application within the USDA IT Process.
- A GNAP initiated by the enterprise network's NOC to address a change in topology of the network.

Both scenarios assume that the latest Baseline of the entire enterprise network is available and consist of:

- A complete network inventory and a physical and/or logical topology
- The usage-based and existing application-based (background noise) traffic associated with the baseline.

In either scenario, it is assumed that GNAP and process elements may be re-executed multiple times (cyclic characteristic). For simplicity, the cyclical characteristic is not considered in the scenarios.

3.6.1 Overview of GNAP invoked by NAITP (Application)

This scenario addresses GNAP being used to modify the enterprise network to add the telecommunications services to a new application identify by the USDA IT process through **NAITP**.

The **RPM** process is entered at the **Environment Assessment** level where application scenario usage, deployment plan; typical application transactions are identified. Application data are **sampled** and QoS attributes are established. From the QoS identified the set of Service Level Agreement **(SLA)** parameters are generated to be fed back to the IT process (Application owner). A set of **traffic profiles** associated with the application is generated. The traffic profiles will eventually end-up in the Application database and become part of the baseline background noise.

Now that application specific profiles are available, the process enters the **Behavior Analysis** phase. From the assessment of the application environment (RPM), a **baseline model specific to the application** can be extracted from the enterprise network baseline. This sub-baseline includes network topology, existing traffic on this portion of the network and the new traffic profiles generated in the RPM model. The **simulation** of the sub-baseline provides the performances attributes of the network portion serving the application and establishes the starting point for the what-if scenarios executed in the next step.

The process enters its final stage **-** Alternative Network Development. The sub-baseline created in the previous step is re-inserted in the Baseline model, if required. The what-if scenarios are executed and the enterprise network resources are modified until the Application requirement (for example, QoS) are satisfied. This results into a high level design of the enterprise network capable of supporting the existing and new applications. The design is forwarded to the enterprise network implementation process and will eventually update the enterprise network baseline.

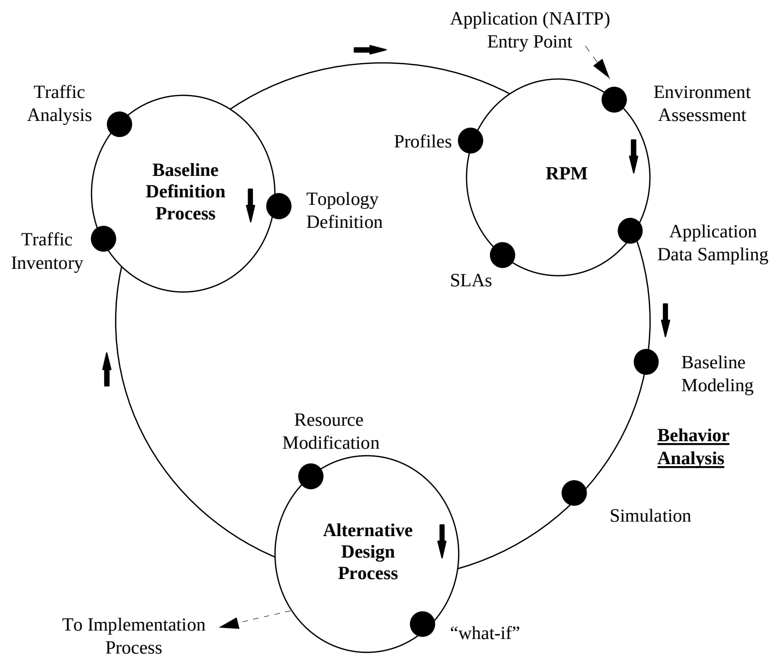

Figure 10 Complete GNAP Initiated by NAITP

In this scenario, all elements and sub-elements of GNAP are being executed.

3.6.2 Overview of GNAP Invoked by the Network Operations Center

The second example addresses the relocation of a certain number of nodes (for example, routers) within the enterprise network. The move is assumed to be geographically localized (from one part of the country to another). In this case, the changes have been identified through the enterprise network's operation center.

The RPM process is also entered at the Environment Assessment point. The move of nodes from one location to another is assessed and applications affected by the move are identified. The Application Data Sampling phase consists of retrieving the affected traffic profiles from the Application database. In this case the SLA's and Profiles already exist and are valid. The associated sub-elements of the process become null.

With the affected application profiles retrieved from the Application database at hand, the process enters the Behavior Analysis phase. From the assessment of the application environment (RPM), a baseline model encompassing the network topology affected by the change is extracted from the enterprise baseline. It may be necessary to have more than one pass in RPM to deal with the portion of the network being removed and the portion of the network being added. In any event, one or more specific sub-baseline model is built including topology and associated traffic. As for the previous example, the simulation of the sub-baseline provides the performance attributes of the network portions being affected by the nodes relocation (the removed and added portions). This establishes the starting point for the what-if scenarios executed in the next step.

The Alternative Network Development phase is entered. The sub-baseline created in the previous step is re-inserted in the Baseline model. The what-if scenarios are executed and the enterprise network resources are modified (re-capacitation) until the requirements associated with all applications affected by the move are satisfied. Note that the requirement (including QoS and SLA's) are part of the information found in the Application database.

A high level design of the new topology of the enterprise network showing the changes in nodes location and required links is forwarded to the enterprise network implementation process and, in this case as well, will eventually update the enterprise network baseline.

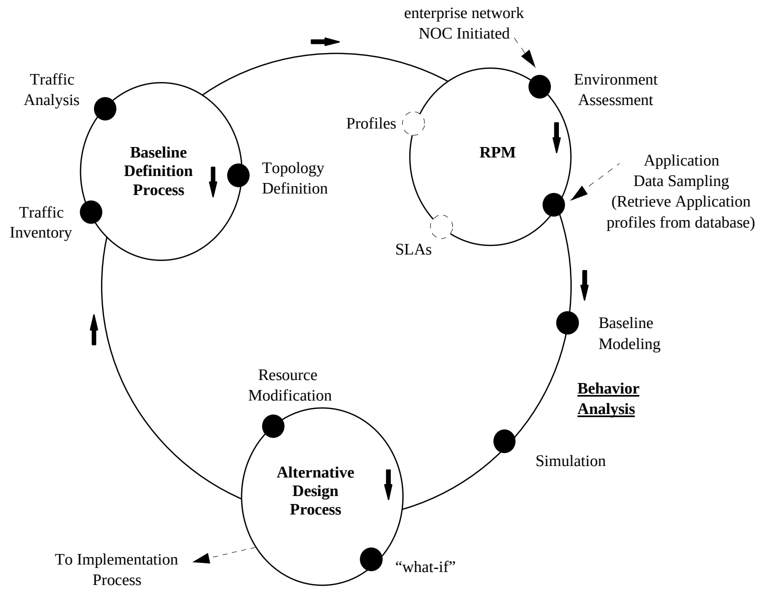

Figure 11 GNAP Initiated by NOC

4.0 Baseline Definition Process

The Baseline Definition Process characterizes an existing network in terms of equipment and usage.

4.1 Baseline Objective

The Baseline provides a comprehensive understanding of how, at a particular point in time, the enterprise network being evaluated is configured and used. It provides the foundation on which all other GNAP activities are based.

To provide this solid foundation, the baseline must include an accurate (as much as possible) topology and characterization of the infrastructure as well as many snapshots of network activity or traffic flow.

4.2 Baseline Definition Process Definition

The Baseline Definition Process is an ongoing activity that includes observation of the changes that occur in the enterprise network over time and allows updating the Baseline accordingly. The Baseline's cyclic aspects and the relationship with other GNAP elements are detailed in Section 3.2.

The Baseline Process documents the following fundamental aspects of the network:

- Current enterprise network topology
- Current utilization of the available network bandwidth
- Application-specific traffic data as available.

In most cases, the Baseline Definition Process uses data collection tools to gather network performance metrics and then uses performance management tools to analyze those metrics to determine the current behavior of the network. While the tools are essential to create the Baseline, other sources of information, such as Network Management System (NMS) reports and telecommunications services billing information, complement and validate the data.

There are three distinct Baseline Definition sub-processes:

- Topology Definition
- Traffic Inventory
- Traffic Analysis

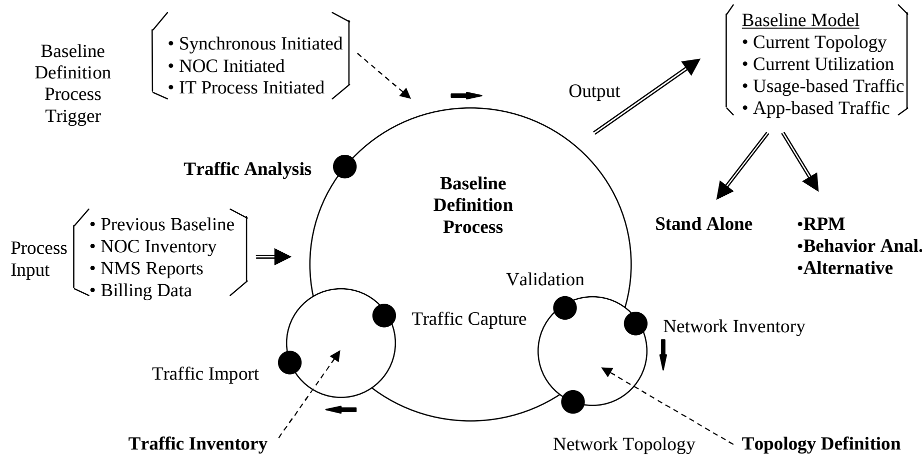

Figure 12 Baseline Definition Process Model

4.3 Process Interfaces

As for any process, the Baseline Definition Process relies on external information (input) and produces information that can be used by other processes (output). The interfaces to the Baseline Definition Process are classified into two categories: a) triggering events and b) input/output data. During Process application, other triggering events and inputs/outputs to the process may be identified.

4.3.1 Baseline Definition Process Triggering events

There are three circumstances identified from which the Baseline Definition Process is invoked.

4.3.1.1 Synchronous

The Baseline Definition Process can be invoked independently at regular intervals as a matter of course. This synchronous initiation of the process is independent of any incidental or planned changes within the enterprise network. This method is considered the normal method to update the Baseline model. The frequency of the Baseline Definition Process is essentially dictated by the resources available to perform the task and the size of the enterprise network being assessed.

4.3.1.2 Network Management Initiated

The Baseline Definition Process can also be initiated by enterprise network operations center (NOC) processes. The Process may be initiated to update the Baseline Model immediately when significant changes are made to the network. The changes include the update of the Baseline Model as the result of the implementation of a new or modified application on the live network.

4.3.1.3 IT Process Initiated

In the normal GNAP, it is anticipated that the GNAP initiated by the IT process via the NAITP would use the most recent Baseline Model as input to the RPM. However, it is possible that the available Baseline Model is no longer current. Initiating the Baseline Definition Process is therefore required prior to continuing GNAP.

4.3.2 Process Input

Following is the set of data and documentation required to create a Baseline Model:

- existing enterprise network documentation such as diagrams, addressing, network devices, and circuit lists
- topology data collected from the enterprise network
- usage-based data collected from the enterprise network
- application-based data collected from the enterprise network.

Although there are various sources for this information, the first one listed below is the most likely candidate.

4.3.2.1 Previous Baseline Model

When the Baseline Definition Process is initiated, only the changes to the previous Baseline model are needed to create the new model. However, this is not always possible because the Baseline Definition Process is very much dependent on the capabilities of network tools used to create the Baseline.

4.3.2.2 Enterprise Network Operations Center

The Baseline Definition Process may also make use of external information to complement and validate a resultant Baseline Model. Such information includes Network Operations Center (NOC) independent network inventory, Network Management System (NMS) discovery and reports, and telecommunications services billing information.

4.3.3 Process Output

The Baseline Definition Process provides appropriate information to generate the current enterprise network Baseline model. The information is generalized below:

- Current enterprise network topology
- Current enterprise network utilization of the available bandwidth
- Current Application-specific traffic[1]

The Baseline Model may be the only requirement applied to the GNAP - stand-alone product. That is, an instance of the GNAP may only be required to produce the enterprise network's inventory, or its topology, or perhaps the entire Baseline model.

During normal operation all GNAP elements—RPM, Behavior Analysis, Alternative Design—use the Baseline Model as a starting point.

4.4 Baseline Definition Procedures

The procedures for creating the Baseline Model may differ depending on the scope of the current GNAP instance and the size of the enterprise network. However, the following guidelines should be applicable in all cases.

4.4.1 Sequence of Events

There may be cases where the GNAP requires only a partial execution of the Baseline Definition Process (for example, enterprise network node inventory). There are three distinct sub-processes to be executed in sequence (for best results) to create the Baseline Model (see Figure 12):

[1] Also called Application background-noise in the GNAP context since it is associated with current network applications.

- Topology Definition
- Traffic Inventory
- Traffic Analysis

4.4.2 Network Inventory Definition

GNAP defines the Network inventory as a list of components comprising the enterprise network. These include:

- network nodes (routers, switches)
- Local Area Networks (Ethernet, Token-ring, Fiber Distributed Data Interface (FDDI))
- LAN links
- WAN links (Dedicated Transmission Services (DTS), Frame Relay Permanent Virtual Circuits (PVC), and others)
- access to carrier services [for example, Points-of-presence (POP's)]

4.4.3 Network Topology Definition

GNAP defines network topology as the relationship between each component of the network. Relationships may be geographical and/or logical. Topology information includes:

- location and configuration description of each network component
- interconnection mechanism for each network component

4.4.4 Network Inventory & Topology Information Gathering

There are several ways to obtain the enterprise network inventory and topology information. If a Baseline Model of the enterprise network exists, the network inventory and topology information gathering requires discovering new elements only.

4.4.4.1 Manual data entry

Using the existing documentation and known information about the enterprise network, each network component (nodes, LAN's, and links) and location can be built in the performance management tool (where the Baseline Model resides). The data entry format depends on the performance management tool used. When dealing with a very small enterprise network, the manual methods are the most time consuming. However, this method can complement other methods described below.

4.4.4.2 Accessing Management Information Base (MIB)

MIB information is retrieved using the Simple Network Management Protocol (SNMP) discovery process. The MIB contains most of the information needed to build a representation of the enterprise network topology.

The SNMP discovery process requires the starting point address of a node (seed address) and the read-only-access-community-string password for each of the internetworking devices that need to be discovered. However, manual techniques (Section 4.4.4.1) are available to ascertain missing data.

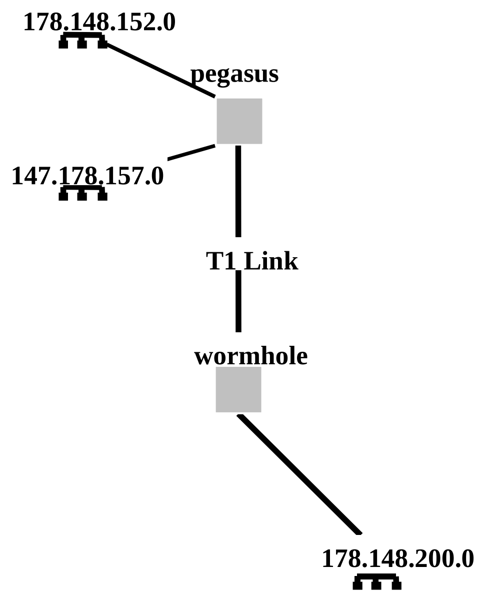

Figure 13 Example of Discovery Topology Map

4.4.4.3 Topology Data from NMS

Most performance management tools, such as HP OpenView, Cabletron Spectrum, and IBM Tivoli NetView, can import data using the map file from a enterprise network management system. Usually this provides a limited, minimal data set that serves as a starting point. This method can also be used to complement the other methods.

4.4.5 Validation

Since the Baseline Model must accurately reflect the current enterprise network, validation of the topology inventory is very important. The model must be thoroughly reviewed and discrepancies found by correlating multiple sources that must be resolved. Discrepancies may result from erroneous MIB data, and incorrectly configured nodes. The validation process includes:

- verifying that all known enterprise nodes are included in the model
- insuring that all nodes, LANs and POP's are interconnected
- validating circuit speeds from the different sources available, including knowledgeable personnel
- validating router information (hardware, vendor, types, protocol configuration as well as addressing)

4.4.6 Collecting Traffic Data

Collecting traffic data documents the amount of traffic on the network to determine enterprise network behavior and create the Baseline Model accordingly.

If a Baseline Model of the enterprise network already exists, the traffic inventory may be limited to collecting the portions of the enterprise network traffic information that is not yet available in the Model and/or Application Database.

Traffic inventory data is derived from two major sources that provide distinct types of data:

- Usage-based traffic data describes both the system trend and the individual circuit utilization within a given time.
- Application-based traffic data provides the overall traffic type distributions and throughput of the enterprise network.

All the collected data must be analyzed to define which samples represent the behavior of the enterprise network.

4.4.6.1 Usage-based Traffic

Enterprise network usage-based traffic is collected from a device MIB to obtain statistics for each interface on the node.

Node Statistics - The traffic usage statistics provide the exact number of bytes that have passed through each LAN interface, WAN circuit, or POP Frame Relay Permanent Virtual Circuit (PVC) interface. This is the most efficient way to determine the total amount of traffic. From this information the percentage of utilization of available bandwidth for each circuit can be obtained.

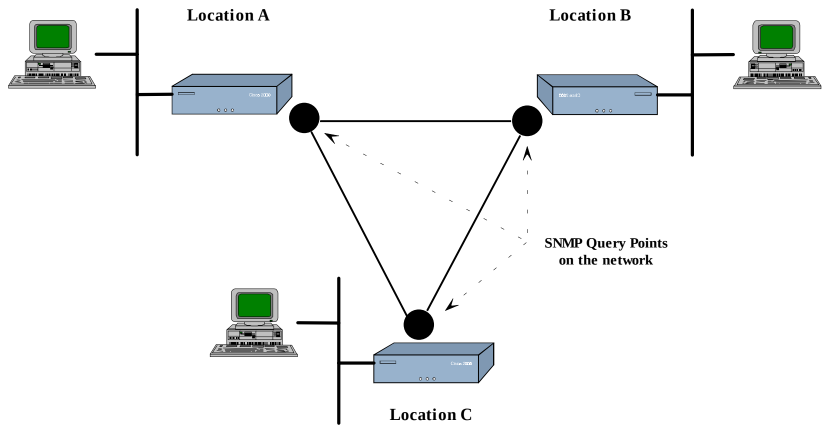

Figure 14 Collection of Usage-based Data

Timing Considerations – The accuracy of data collected for the Baseline Model is directly proportional to the sampling time. The collection time interval should be set to show the network traffic load maximum and minimum values. However, the time interval should not be too large that when computing the average load in kilobytes per second (kbps) the maxima and minim are lost. An accepted industry standard is five minutes sampling.

It is also important to determine whether there are specific business processing cycles that need to be captured. One must realize that peak time determination is affected by a) the size of the enterprise network being addressed by the current GNAP cycle, b) the diversity of applications operating on the network, and c) the geographical spread of the enterprise network, that is crossing time line boundaries.

Also, for the enterprise network being evaluated, all nodes should be queried quasi-simultaneously. This allows data obtained from the nodes to be combined to calculate the volume of data for the entire enterprise network for any given time.

4.4.6.2 Application-based Traffic

Application-based traffic is collected by using either traffic analyzers or RMON2-compatible probes. A primary consideration is that the format of the data obtained from collection devices be compatible with the performance management tool where the Baseline model resides.

Probe Placement Strategy - In most cases, the enterprise network is much too large to allow placement of probes at every node of the network. It is important that probe placement create a focused and cost-effective data collection strategy. Depending on the objective of the Baseline Definition Process, the probe placement strategy can be very different. The two steps to be considered are:

- identifying the primary enterprise network resources for the applications. The information obtained from the usage-based traffic can help greatly toward that goal.
- identifying possible paths for the traffic of interest.[2]

Timing Considerations – For valid, reliable application-based traffic data, use the same time period and the same data collection intervals as for the Usage-based data collection.

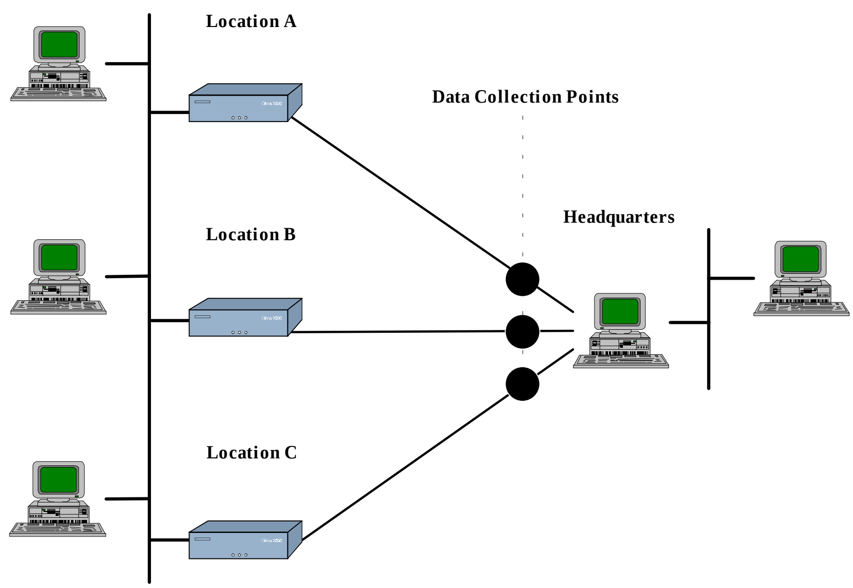

Figure 15 Collection of Application-based Data

In most cases, the probes currently available on the market allow remote configuration. In the other cases, correlated data collection will be needed (synchronization of sampling interval and start/stop times).

[2] Enterprise network WAN backbone circuits (if existing) are usually the path for critical application traffic (field office to headquarters).

4.4.7 Traffic Analysis

When both Usage-based and Application-based samples have been collected, all the data must be analyzed to determine the current enterprise network behavior and determine which samples best represent that behavior.

Use the Performance Management tool to analyze Usage-based data to establish available bandwidth and how it is used. Analysis of Application-based data identifies the major traffic types in transit within the enterprise network and define how applications use resources. Analysis results are dependent on performance management tool functionality.

4.4.7.1 Usage-Base Data Analysis

Use of the enterprise network is evaluated from information derived from the Usage-based data obtained during the data collection phase. The usage is assessed for each selected time period. The peak (worst case) time is identified. The percent utilization (percentage) is also identified to determine the critical path across multiple selected time periods.

4.4.7.2 Application-based Data Analysis

The application-based data analysis characterizes the behavior of individual applications and hosts. It may include:

- **Application Distribution –** Provides application types such as File Transfer Protocol (FTP), system Network Architecture (SNA), Hyper Text Transfer Protocol (HTTP), and others with the network resources metrics used by each application.

- **Network Conversation Behavior –** Identifies, by application and/or host, and characterizes, by the conversation time, the number of bits per second in forward and reverse directions, and other related metrics (See Table 1).

- **Application Throughput -** The throughput of an application, usually expressed in kbps, shows the specific bandwidth used by a particular session within a given time period.

Network Protocol	Source Address	Destin. Address	App. Type	Start Time	Stop Time	Byte Forward	Byte Return	Packets Forward	Packets Return
IP	xx.xx.xx	yy.yy.yy	http	1/2/99 15:31	1/2/99 15:31	40,870	8,468	74	146
IP	zz.zz.zz	nn.nn.nn	TCP	1/2/99 15:31	1/2/99 15:31	227,100	454,200	3,785	7,570

Table 1 Samples of Enterprise Network Conversations

4.4.8 Finalizing the Baseline Model

Usage-based data provides information on enterprise network utilization and application-based data provides information on the application conversations that generate the utilization.

Usage- and Application-based data can be used to correlate each other. Consistent high utilization of a given circuit can help define which application causes the use on that circuit.

The Usage- and Application-based data should provide enough information to create the enterprise network Baseline Model.

The Baseline Model should include the following

- Relevant traffic generating elements
- Sufficient traffic samples to define a typical use for creating the background-noise traffic
- Periods of heaviest use

4.4.9 Maintaining the USDA EN Baseline

Keeping the Baseline Model current has been addressed briefly in Section 3.2. The factors warranting a Baseline Model update can be classified in two major categories.

- **Topology changes** - Changes affecting the topology are usually the addition of network nodes (routers), configuration changes (circuit speeds), the addition of circuits, or changes in location.

- **Network Utilization** – Traffic volume and use on individual links (especially network backbone links) as well as new Usage-based data must be compared to new Application-based data describing distribution and throughput changes.

In theory, changes in the network not introduced by the NAITP process are initiated by the enterprise network operations center (NOC) procedures. However, it is inevitable, especially for large organization network(s) such as the USDA, that changes will sometimes occur outside the process. Therefore, the Baseline Definition Process must be performed at short, regular intervals.

5.0 Resource Planning Methodology

The Resource Planning Methodology (RPM) determines the adequacy of the current enterprise network to handle planned network changes. RPM allows such determinations by providing information about the network resources that must accommodate the changes.

5.1 RPM Objective

The RPM focuses on characterizing the behavior of changes planned for the enterprise network. It characterizes demands placed on the USDA enterprise networks by new or modified applications, removal of applications, and network topology changes. Furthermore, the quality-of-service (QoS) level that a new application can deliver to its users can be ascertained based on the behavior of the enterprise network, or portion thereof, over which the application is running. Consequently, a set of Service Level Agreements (SLA) related to the supportive network can be defined.

5.2 RPM Definition

The RPM may be considered the most important element of GNAP because it characterizes the demands of applications on the enterprise network.

Depending on the requirements, the RPM may be the only element, other than the Baseline Definition Process, that may be executed during the current GNAP cycle. QoS values and SLA's resulting from the RPM may be all that is necessary to fulfill the GNAP objectives.

Two major network design activities initiate the RPM process:

- enterprise network changes associated with new or existing applications
- enterprise network infrastructure changes which are independent of existing applications

The execution of RPM, if initiated by the USDA IT Process, requires close cooperation between the Application Development and the Network Engineering teams. In the same spirit, if RPM is initiated by the enterprise network management process, there must be a close cooperation between the NOC organization and the Network Engineering team.

The four sub-processes associated with RPM (Fig. 16) are:

- Environment Assessment
- Application data sampling

- Service Level Agreement generation
- Profiles creation

Each of the sub-processes is addressed in detail in this section of the document.

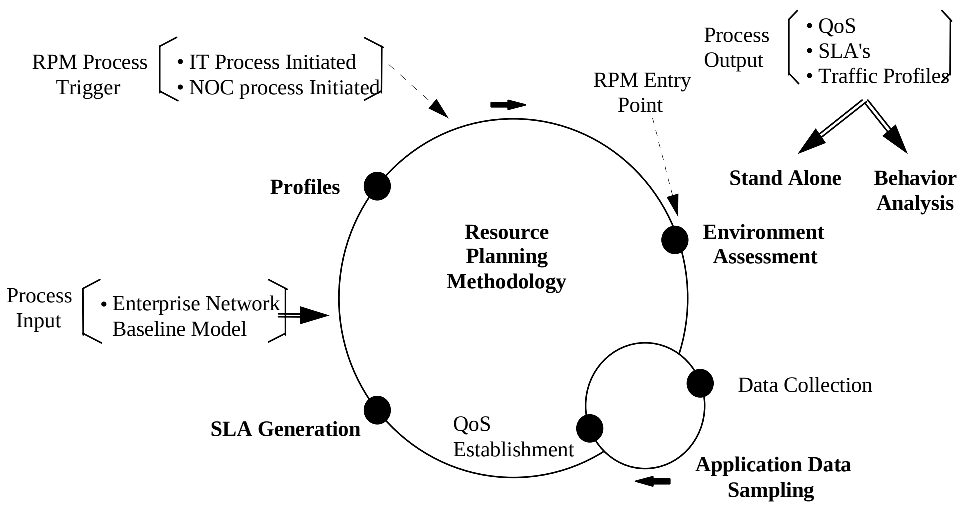

Figure 16 Resource Planning Methodology Process Model

5.3 RPM Interfaces

Prior to reviewing the different elements or actions that comprise the RPM procedures, it is beneficial to have a high level of understanding of the GNAP circumstances that initiate the RPM process and define the input and output of the process.

5.3.1 RPM Triggering

As mentioned previously, RPM may be triggered by the IT Process via the NAITP or the enterprise management process.

In most cases, the RPM is the entry point of the GNAP. It is assumed that in those cases the Baseline model reflects accurately the current status of the enterprise network.

5.3.1.1 RPM Initiated by the IT Process

The IT Process by definition will always result in a requirement to deploy one or more applications. However, only the applications requiring telecommunications services are subjected to the GNAP. Resources can be planned based on the introduction or assessment and modification of current applications.

Within the USDA IT Process model the NAITP identifies applications requiring the services of the enterprise network. When the NAITP indicates that an application requires enterprise network services, the GNAP is initiated at the RPM level. The NAITP ensures the readiness of the enterprise network to support new or enhanced existing applications. The NAITP uses known sources of systems planning information, known application developers and serendipity to identify systems that have potential impacts on network resources.

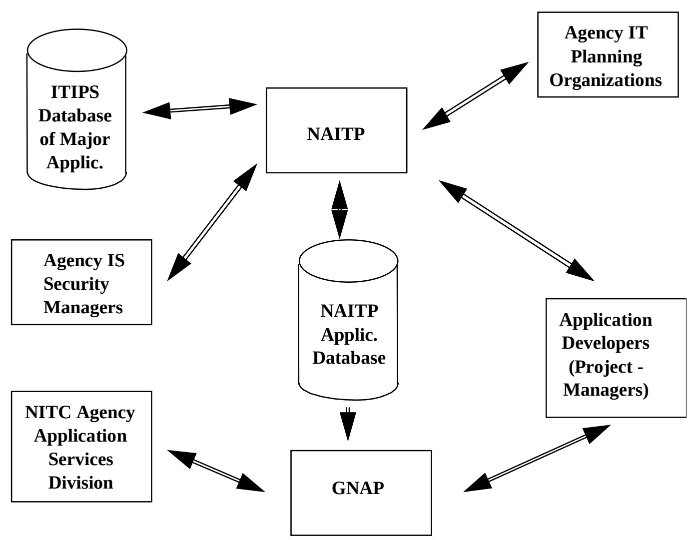

Figure 17 Source of Application Information Overview

The NAITP is documented in another document: Network *Application Identification Tracking Process*, In Progress

5.3.1.2 RPM Initiated by the NOC

To modify the enterprise network infrastructure, resources can also be planned independent of the applications currently running on the network (for example, geographical changes of network nodes). In this case the enterprise network utilization remains the same while nodes and links characteristics change. Usually these changes are initiated by the enterprise network management process. The elements of the process that can trigger the RPM include:

- trouble ticket

- observation / suggestion on the current status of the enterprise network
- inventory changes within the network
- circuit utilization changes
- application on production enterprise network

5.3.2 RPM Input

In most cases, the RPM depends on the execution of at least one cycle of the Baseline Definition Process—enterprise network Baseline Model. In the case of the GNAP/RPM initiated by the enterprise network NOC process, the application traffic affected by the topology change needs to be identified.

5.3.3 RPM Output

There are three items that may result from the RPM Process; two are stand-alone items while the third is input to the Behavior Analysis Phase of GNAP. Which item is produced is dependent on the GNAP/RPM initiation method. In addition, depending on the GNAP initiation strategy, one or more output item may be required. For example, the GNAP strategy may call only for the generation of a set of SLA's for a new application.

Trigger Modes	Process Output
IT Process	**QoS**, **SLA'**s, New **Application Profiles**
Network Management	Identity of existing **Application profiles** (in the Application Data Base) affected by the change of topology

Table 2 Resource Planning Methodology Output

Under normal circumstances RPM is followed by Behavior Analysis of changes required to support applications or topology changes.

5.4 RPM Activities Procedures

This section of the document provides guidelines for planning the resources necessary to address enterprise network required changes. The main goals of this GNAP sub-process involve creating profiles of the planned enterprise network changes (new / existing applications or topology modifications). The profiles are created by measuring application transactions to determine the demands the application is most likely to make on the network.

Attributes that define quality of service (QoS) and service level agreements (SLA's) become by-products of this process. One must keep in mind that, based on the GNAP objectives, not all products of the RPM process may be required and that RPM could be the last step in GNAP.

The complete RPM process is made of four elements (see Figure 16):

- Environment Assessment
- Application data sampling (generic application is implied here)
- Service level agreement Generation
- Traffic profile generation

It is important to reiterate that more than any other element in GNAP, RPM requires a very close cooperation between the USDA organizations that are directly or indirectly responsible for the initiation of GNAP. In particular, cooperation between the network development team, application developers, and the enterprise network operations center (NOC) is mandatory.

5.4.1 Environment Assessment

The environment assessment is a very important step and care must be taken when doing so. The initial GNAP objectives (reason for which GNAP is invoked) must always be kept in mind when performing the assessment. Assessment out-of-step with the strategy can lead to erroneous information gathering.

While some of the information gathered in this step will be used in subsequent GNAP steps, a detailed understanding of the environment subjected to the planned changes is required prior to entering the application data sampling phase. Data sampling targets specific application transactions including the application that may be affected by a network topology change.

5.4.1.1 Application Deployment Location

The location of the application specific hardware (clients and server(s) is required. The location information provided should be sufficient to correlate the information with the enterprise network topology inventory. This information is required in subsequent GNAP phases to identify the additional existing background traffic.

5.4.1.2 Number of Users

The number of application users or in the case of network topology change, the number of user affected by the change is needed. This information can be used to build or modify application profiles. There are no strict rules for generating this number. The number of users can be extrapolated from the number of users for similar applications or the number of users at similar sites.

5.4.1.3 Selecting Transactions

The selection of application transactions is used to derive application profiles. The GNAP objectives guide the selected application transactions used to obtain the frequency of transaction and to provide guidance on the typical transactions used in the creation of traffic profiles. Typically, traffic profiles are created from frequently used transactions because they establish the worst case traffic volume—necessary for sizing network links required to support the application. Transaction frequency is the number of times one user repeats one of the application activities (transactions) within a time unit.

To select the set of transactions that can be used to define application profiles or select existing ones, a set of high-level characteristics are defined.

- Transactions should represent the normal expected application activity used relatively frequently
- Transactions should be time-correlated with the usage-based and application-based traffic comprising the enterprise baseline (see Section 4.4.6.1 - *Timing Considerations*).
- Transactions must generate traffic across the enterprise network WAN links.

5.4.1.4 QoS Goals

From the application development perspective, the QoS is the metric quantifying end-to-end delay. The enterprise network delay is only one element contributing to the delay. The other element is associated with application execution delays (server and client). To define acceptable network performance, a QoS goal for a particular application must be established as a baseline. This goal includes a target figure for delay and bandwidth requirements.

5.4.1.5 Assessing Effects on the Network

This part of the assessment is much less tangible. This is to assess, in a general ways, how the changes will affect the enterprise network as a whole. This assessment includes identifying the current application distribution (from the enterprise network baseline model) and determining the effect or distribution of new applications being introduced or old ones being removed. Also one must consider the effect on the network of the new and old applications temporarily coexisting.

This assessment is particularly important for changes that affect only the enterprise network topology. Traffic pattern changes, link addition and deletion, and routing strategy needs to be considered

5.4.1.6 Environment Assessment Summary

Information requirements and plans for the Environment Assessment Summary include:

- Requirements
  - availability of knowledgeable application users
  - selection of meaningful application transactions
  - execution frequency of application tasks
  - execution timing of application transactions
  - number of users that might perform a transaction simultaneously
  - QoS goals
  - effects of application /addition on the whole enterprise network
  - effects of topology changes within the enterprise network
- Plans
  - Coordination Plan between the application development, network development, and enterprise network operation center organizations
  - Deployment Plan of the application, including location

5.4.2 Application Data Sampling

Application data sampling is the process for obtaining data to create an enterprise network traffic profile of an application. Theoretically, if the objective of the current GNAP cycle is to use existing profiles from the NAITP application database (for example, the case of enterprise network topology changes), then this step of the process is basically null. However, there may be cases where the existing profiles may need to be updated and data sampling would be required.

5.4.2.1 Tool Considerations

Application sampling is done with traffic analyzers (also called probes) connected to an appropriate point in the network. Collection devices sample the traffic data identified during the transaction selection phase as pertinent to the application.

Traffic analyzers must satisfy the following criteria:

- Capable of capturing network layer conversations data between the source and destination
- Capable of time-stamping the conversation with start and stop times
- Able to sample the traffic bi-directionally between end points
- Provide data in a format compatible with the performance management tool used in the GNAP. Table 1 in Section 4.4.7 shows typical application conversations as captured with a typical traffic analyzer.

5.4.2.2 Testing Environment

The application operating environment—the location where two endpoints (client/server) and the traffic analyzer will be placed—must be defined. The two environments identified represent an isolated environment (separate from the actual enterprise network) and the actual live enterprise network itself. When possible the isolated (laboratory) environment should be used. This is often possible when new applications are being developed. This isolated environment includes all components required for supporting the application (that is, server, client, LAN, WAN and tools). In some cases, however, it is not possible to use the isolated environment and the actual live network must be used.

Isolated Environment - The main advantage of the isolated environment, other than logistic coordination of the data capture, is that it permits capturing traffic data that will generate pure traffic profiles. These pure profiles are not contaminated with existing traffic and will not be affected by the actual uncontrollable network bottlenecks and propagation delays.[3]

In the isolated environment, WAN simulators generate the bandwidth and delay characteristics of various enterprise network circuits. The isolated environment has several benefits including greater flexibility in the different scenarios and the ability to accurately reproduce the same scenario.

The isolated environment creates the anticipated network delay of the deployed application and is a critical element for establishing the QoS parameters.

Live Network – When application testing cannot be performed on an isolated network environment, testing must be performed on a live network. With a live network, it is very difficult to control the behavior that characterizes the traffic (for example, delay variation). Depending on the GNAP objectives, the conversation can be captured on circuits that provide worst case response. This provides some sense of the QoS that can be expected.

5.4.2.3 Gathering Application Traffic

Obtaining application data requires a highly coordinated effort between the knowledgeable user and the individual who monitors the gathering of data using the traffic analyzer.

The traffic analyzer used to capture the data should be placed between the two end-points of the conversation selected to be included in the profile(s). Although the analyzer can be placed anywhere on the link, it is recommended that it be placed close to the end-point where the benchmark is run (client). Depending on the GNAP objective, the analyzer may be placed on LAN and /or WAN links.
The WAN delay simulator allows the testing of multiple WAN scenarios with different bandwidth and delays. This is

[3] It is understood that eventually the application will be deployed on an actual network and will need to contend with those factors.

important for determining the point at which quality-of-service goals are no longer met.

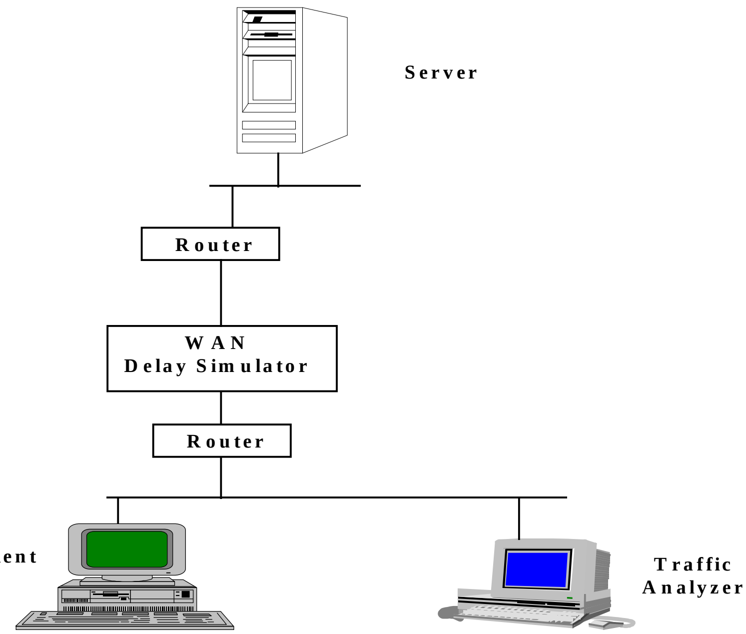

Figure 18 Example of Test Bed Environment

Depending on the environment and the objectives, there are process variations on how to create the transactions and record the results. However, a set of common steps can be identified in this process.

BEGIN

For each transaction selected in the benchmark do

begin

Data collection device starts collection; and Records capture of interval starts.

Application selected transaction is run;
Start time of transaction recorded.

Application selected transaction is completed;

Data monitoring process stops;
The data captured is saved; and
Termination time of capture is recorded.

end;

END;

5.4.2.4 Application Quality of Service Definition

In the GNAP, the QoS is the application performance viewed from the user perspective in term of response time and throughput. In many cases QoS is very subjective (for example, tolerance by the user of the low number of transaction that can be executed in a given period of time). In some cases, however, delays may causes failure of the application - SNA applications are notorious for being sensitive to delays.

From the enterprise network perspective, QoS is the network's ability to match service with user and application requirements. The WAN simulator is a very useful tool to define the delay and the bandwidth availability that can support the application. A process of elimination is used by changing the characteristics in the WAN components of the application network and observing the threshold where:

- the bandwidth available is enough to support the application
- the knowledgeable user is no longer satisfied by the response time observed on the selected benchmark transactions.
- the application actually fails execution of all or some of the task's transactions.

To provide 'trusted' parameters, each of the test defining delays should be repeated multiple times.

The knowledge of the enterprise network portion that will be affected by the application (see *Environment Assessment*) can also be used to complement the delay simulation process, that is, identifying a worst-case situation.

5.4.3 Service Level Agreements (SLA) Generation

The SLA defines the responsibilities of both the enterprise network service provider and the user of those services. Within the USDA network design process, the SLA's are divided into two main components: administrative and performance. The administrative portion addresses requirements placed on the enterprise network operation center (NOC) procedures such as problem-reporting procedures, condition of escalation to the next level of support, and so on. The administrative aspect of an SLA is not addressed in GNAP.

However, for information purposes, a guideline for establishing an SLA is provided in Appendix A.

The performance aspect of the SLA includes two attributes that can be derived from the QoS establishment (see section above):

- Average response time and highest (worst case) response times of the enterprise network providing service to the application.
- Available bandwidth requirement that the application needs from the enterprise network services.

It also may be beneficial to the Application 'owner' to understand how these metrics are calculated and how frequently they are reported.

5.4.4 Application Profiles

This process, the last stage of RPM, creates traffic profiles from the transactions captured during the application data sampling. In most GNAP instances, a performance management tool is required to create the application traffic profiles. The methodology used to build profiles is dependent on the tool being used.

To create a profile of selected transactions representing the application traffic, the following information per transaction is needed regardless of the performance tool being used:

- identification on the type of network media where the data was collected (Ethernet)
- network protocol used (IP);
- start and stop time of the conversation representing the transaction
- total number of bytes transferred in forward and return directions
- average packet size in the forward and reverse directions

The table below shows an actual set of transaction profiles associated with the USDA's Combined Administrative Management (CAM) application as prepared using Make System’s NetMaker XA® Performance tool.

Transaction type	Protocol	MAC	Pkt. Fwd.	Pkt. Rtn.	Pkt. Ratio	Bytes Fwd.	Bytes Rtn.	Rate	Max. Kbit/s	Min. Kbit/s
CAMS-Casual	IP	Ethrt.	194	480	1.22	1121	2273	.16238	3	0
CAMS-Power	IP	Ethrt.	194	480	1.22	1121	2273	.27064	3	0
CAM_sm_ transaction	IP	Ethrt.	808	265	1.04	19396	6113	.04761	7	0
CAM_sm_ transact._lan	IP	Ethrt.	530	72	4.4	56235	1735	.14266	64	0
CAM_sm_ transact._wan	IP	Ethrt.	808	265	1.04	19396	6113	.04761	7	0
cam_login_lan	IP	Ethrt.	1414	67	1.79	2868283	76137	.02633	1116	0
cam_login_wan	IP	Ethrt.	612	235	0.94	17775	7285	.02272	3	0
cam_med_cach-ed_wan	IP	Ethrt.	484	333	0.74	2163	2003	.090991	1	0
cam_medium_ lan	IP	Ethrt.	1449	63	1.62	98062	2639	.7	721	0
ca_medium_ wan	IP	Ethrt.	339	222	0.79	1974	1636	.12262	2	0

Table 3 USDA CAMS Application Transaction Profiles

5.4.5 Next

The creation of profiles for a particular application is the last step and the main goal of the RPM. Profiles are placed in the application database (see Figure 17) and can be retrieved for use in a subsequent GNAP associated with the same application (improvement and/or modification of the application within the related IT process) or for new, similar application development.

As previously mentioned, depending on the GNAP objectives, the RPM may only be partially executed. Perhaps, the only requirement needed is generation of the QoS and / or SLA's that require support by the enterprise network services for the application under study.

The logical next step after the RPM process, if GNAP requires it, is to perform the behavior analysis of the enterprise network, or portion thereof, identified to support the application.

6.0 Behavior Analysis

The Behavior Analysis phase provides an assessment (educated predictions) of how the enterprise network or portion thereof will perform when subjected to the planned changes described by the GNAP objectives. The output of this process, mainly performance attributes, has independent significance. They quantify, in a tangible way, the effect (positive or negative) of proposed changes on the entire enterprise network. If required, the Behavior Analysis provides the new baseline from which the Alternative Design Process starts (next GNAP sub-process).

6.1 Behavior Analysis Objective

In the classical network design sense, the Behavior Analysis phase could be considered part of the Alternative Design Process. The USDA GNAP isolates this portion of the process to provide a stand-alone deliverable describing the effects of the planned changes (application or/and topology) on the current enterprise network. This may very well be the objective of the current GNAP cycle. On the other hand, the new baseline generated may be used as the starting point for the Alternative Network design to support the requirements.

6.2 Behavior Analysis Definition

The Behavior Analysis assesses the enterprise network behavior predictions by creating a new baseline model which is made of the initial baseline model and the planned changes (topology and/or application) using the information obtained from the RPM. Once a new model is built, a simulation is run on the newly created baseline model to assess network performance and available resources. No optimization is intended in this sub-process.

Two steps are identified in the process:

- Create the baseline model: New Baseline Model = enterprise network baseline + RPM by-products.
- Simulate a run on the new baseline

6.3 Process Interfaces

Unlike the other cyclical elements of the GNAP, Behavior Analysis is linear. The baseline is created and a simulation is run on the baseline but no changes are implemented as a result of the process. Behavior Analysis is always triggered by the RPM process and uses the enterprise network baseline; the RPM generated traffic profiles and, if appropriate, traffic profiles from the application database. The output of Behavior Analysis is a set of performance attributes related to the required changes. If required, the process may be directed to the Alternative Design Process.

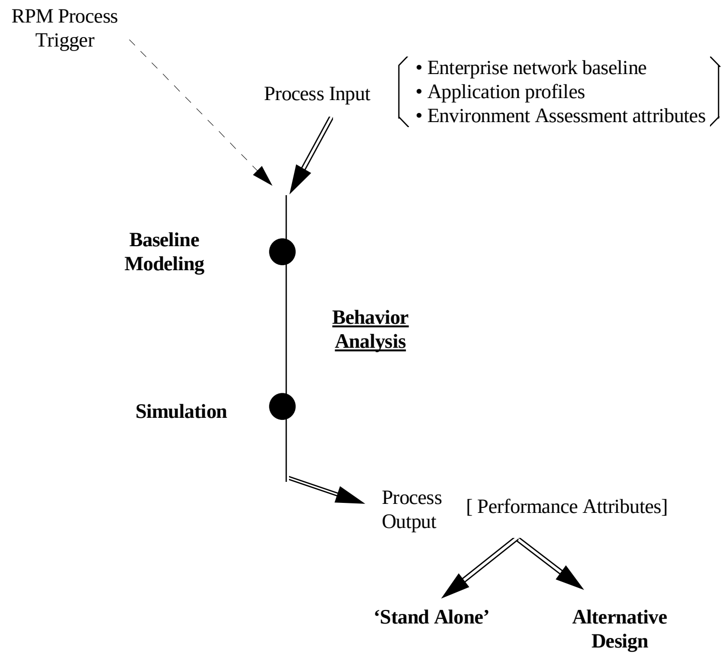

Figure 19 Behavior Analysis Process Model

6.3.1 Behavior Analysis Trigger

Regardless of the GNAP objectives, the Behavior Analysis Process is always triggered by the **RPM**.

6.3.2 Process Input

The Behavior Analysis Process is analytical. It depends on the current **enterprise network baseline**, which includes topology, usage-based and associated application-based data (background traffic). It is assumed that the current enterprise network baseline is free of impairments such as undersized links and bottlenecks.

The process needs the output from the RPM process, mainly the **application profiles** associated with the changes. The application profiles may be generated by the RPM or may be selected from the application database.

Environment Assessment attributes such as the location of an application's server/client, the number of users and so on, identified during the Environment Assessment phase of RPM are required.

In most GNAP cases, a performance management tool to perform the analysis is required.

6.3.3 Process Output

The output of the Behavior Analysis Process is mainly a set of **performance attributes** that can be analyzed and compared with QoS specifications established from the RPM. If changes are not directly related to new or modified applications, the application affected by the changes is identified in the application database with its associated QoS. The attributes include amount of transaction delay and circuit utilization, which can be translated to available bandwidth.

The performance attributes related to the required changes may be the **final product** of GNAP. However, the new baseline created in this process is the starting point of the **Alternative Design Process**.

6.4 Behavior Analysis Procedures

The goal of the behavior analysis, as a part of GNAP, is to evaluate the effect that the changes dictated by the GNAP requirements may have on the enterprise network. This process relies on the information already obtained in the Baseline Definition Process and RPM processes. There are two components in this process:

- Create a new baseline; and
- First time simulation run on the new baseline

6.4.1 Create the New Baseline

The new baseline created in this phase consists of data derived from the most current enterprise network baseline and additional information obtained in the RPM process.

6.4.1.1 Enterprise Network Baseline as the Base

As defined in this document, there is no size defined for the enterprise network—it can be very small with only a few nodes (routers) or, like the USDA combined networks containing thousands of nodes, it can be very large.

If practical (in terms of size), the new Baseline Model base (network components from the current enterprise network baseline) may be composed of the entire baseline or several merged enterprise network baselines. However, operational simulations on a large network model are inordinately clumsy, complicated, and time-consuming. In this case, the new Baseline Model base directly associated with the new changes (for example, geographically relevant) may be extracted from the Baseline Model. The new Baseline Model base may also be extracted for other reasons such as the limited capability of the performance management tool to handle large networks.

When the extracted method is used, one must be very careful to extract the associated topology and background traffic (user-based and application based traffic). It must also be noted that eventually the extracted network model may need to be re-inserted (merged) into the original enterprise network baseline model (for example, the Design Alternative Process). An extracted baseline model should be validated to ensure that all the links are terminated on both ends (avoiding hanging links) and all associated traffic has a source and destination.

6.4.1.2 Create the New Baseline Model

The new baseline is actually an abstraction from reality. This model creates a set of performance attributes related to the changes required. (for example, a new application).

The type of baseline model needed must be defined. Depending on the GNAP objectives, the baseline may be worst-case scenario, average scenario, or something in between. The selection is instrumental in the choice of background traffic applied to the topology (for example, peak-time user-based traffic for worst-case).

Once the base for the baseline is established, the new baseline is created from usage-based data obtained or identified in the RPM. The information obtained during the Environment Assessment (location of users, number of users, transaction frequencies) is used to determine where and how to load the application profiles onto the baseline. The application profiles created and/or identified in the RPM are added to the model to represent the additional traffic load created by the requested changes.

In most GNAP applications, multiple scenarios—what-if scenarios—(for example, worst-case and normal case) can be used during the Simulation Phase and the Alternative Design Process.

6.4.2 Simulation

It is in this phase that the first simulation task on the new baseline is performed. The new baseline (entire or partial) is assumed to be loaded in the performance management tool and the simulation is ready to be run to completion. Depending on the tool used, various results can be generated from the simulation. In any case, the performance management tool should be capable of providing:

- The routing of the network conversations as simulated.[4]
- The bandwidth utilization for all network components within the new model including WAN circuits, LANs, routers, and hosts.
- The response time on a packet basis in both forward and reverse directions for individual conversations in the model.

6.4.3 Next

It is worth noting that the results obtained from this simulation are as is (good or bad), qualifying the changes that are potentially implemented on the enterprise network. The results from this simulation may be the final objectives of GNAP. This result may also be complemented with the QoS and SLA attributes obtained in the RPM.

It may be possible, though not likely, that the performance results are satisfactory relative to the QoS established in the RPM. This would be true only if the entire original enterprise network model was also used as the new baseline base. In the case of the extracted baseline, the new baseline needs to be re-inserted within the original baseline to observe the full effects of the changes on the entire enterprise network model. The effects are directly proportional to the extent of the changes—a limited new application deployment would have minimal ripple effects on the entire network.

The assessment of how the changes are to be implemented within the enterprise network is the subject of the next and last GNAP—Alternative Design development.

---

[4] That is, how the traffic gets from source to destination including the network components traversed (hosts, routers, LANs, WAN links). The routing is different depending on the routing protocol selected for the simulation [for example, Routing Information Protocol (RIP), Open Shortest Path First (OSPF)].

7.0 Alternative Design

The design of network alternative(s), the last stage of the GNAP, produces high level network design guidelines (modification of the current enterprise network) to support the changes established by the GNAP objectives. The objectives may be the addition, deletion, or modification of application support or may simply be a change required in the topology of the network. The output of this process is a guideline used to implement a pilot test of a particular application or can be forwarded to the enterprise network operation process for implementation.

This section provides only general guidelines for the Alternative Design Process. The details of this process are dependent on the initial objectives of GNAP, the performance management tool used in the process, and the size of the enterprise network, all of which can vary greatly.

7.1 Alternative Objectives

This process is a continuation of the Behavior Analysis Process started during the previous GNAP task. The objective of the Alternative Design Process is to provide guidelines for redesigning the enterprise network to support proposed changes (for example, additional load caused by a new application). The redesign of the enterprise network is limited to changing the capacity and the type of links. Some new routing and topology optimization can also be done. However, an accurate optimization requires the availability of application-based traffic between each end-point of the network. Although this is not likely to be available on a large enterprise network, extrapolation of similar application traffic may be used to compensate for insufficient information.

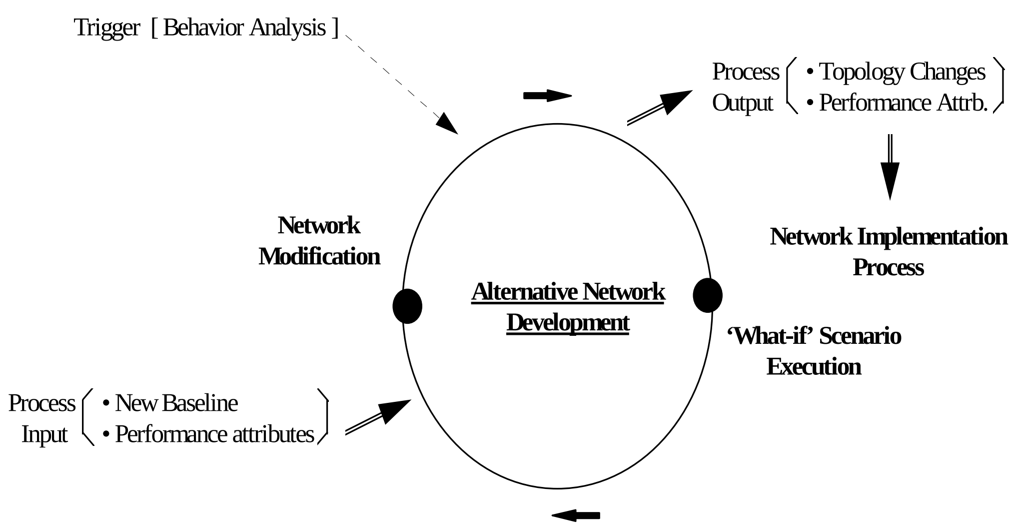

Figure 20 Alternative Development Process Model

7.2 Alternative Design Interfaces

Since it is a continuation of the Behavior Analysis Process, the Alternative Design Process uses all components of that process. The output consists of information that satisfies the objectives and that is pertinent for implementing the changes. It includes node changes (addition/removal of nodes), circuit changes, and new routing requirements.

7.2.1 Triggering of the Alternative Design Process

The triggering of the Alternative Design Process is the natural continuation of the task started in the Behavior Analysis Process.

7.2.2 Alternative Design Process Input

The input to the Alternative Design Process is the enterprise network new baseline generated in the previous task. This may be the entire original baseline plus the additional network configuration supporting the planned changes or the partial, extracted baseline with the additional network configuration.

The initial set of performance attributes identified in the Behavior Analysis Process is retained for comparison purposes when optimizing the enterprise network. It includes routing information, bandwidth utilization, and response time. Initial GNAP requirements and QoS attributes are used to drive the optimization process.

7.2.3 Alternative Design Process Output

The Alternative Design Process output is dependent on the GNAP objectives and the performance management tool used. The process should provide enough information so that implementation of a new topology (nodes and circuits) guideline helps implement the changes on the real or pilot enterprise network.

Additional performance information, usually derived from network management tool reports, is also valuable for the implementation process. This includes delay assessment, link utilization, and survivability assessment.

7.3 Alternative Design Procedures

The Alternative Design Process described provides the general guidelines to produce network a design alternative(s) capable of supporting the network changes defined by the GNAP objectives. There may be more than one alternative design produced by the Alternative Design Process.

Redesigning the network is an exercise that uses the performance management tool to analyze and reconfigure the enterprise network's new baseline model until the QoS specifications are met and maintained for all affected applications.

7.3.1 Starting Point of the Alternative Design Process

If the baseline created in the previous GNAP step (Behavior Analysis) is the entire original enterprise network baseline model with the additional changes identified in RPM, then this model is the starting point for the Alternative Design Process.

Alternatively, if the new baseline is actually made of an extracted portion of the original baseline with the additional changes identified in RPM, then this new baseline needs to be re-inserted into the original baseline model to create the alternative design baseline starting point. In this case, a validation of the model is required before running the simulation.

7.3.2 Simulation and Analysis

While the initial simulation during the Behavior Analysis may have produced acceptable results (assuming the simulation was run on the entire baseline), it is a good idea to run the simulation again in this stage, perhaps with new scenarios.

The analysis consists of evaluating the results of simulations to determine whether the predicted behavior of the network, as a whole, meets the original objectives. The main point of the analysis in network design is to look at predicted values of response time (delay) and compare them with the QoS value established in the RPM. If the delay is proved to be unacceptable, then one must find the components in a particular conversation route (round trip) causing the problem.

7.3.2.1 Routing Issues

Incorrect routing configuration within the model may be the cause of bottlenecks by creating routing loops, or failure to route the traffic to its correct end-point. In particular, this may occur when crossing the boundary between two different routing domains [for example, RIP/Internet Gateway Routing Protocol (IGRP)].

7.3.2.2 High Utilization

High utilization of various components within the route of the conversation (LAN, WAN, internetworking components) may also cause delays. Analysis may identify network components where high utilization may cause output queue delays affecting the per-packet response time.

The amount of delay within a network is directly related to the utilization. Utilization of a specific resource has a direct effect on the average delay of the resource handling queue. Queuing and/or buffering can contribute to excessive delay within a network.

To a lesser degree, processing time within the nodes of the network (filtering, traffic accounting) can cause delays.

7.3.2.3 Response Time

It is assumed that the performance management tool can show the average forward and average return per-packet response time. Estimate of total round-trip time on a per-packet basis can be calculated by adding forward and reverse delays. Note that this does not include the end-point delays (for example, client / server).

7.3.2.4 Survivability

The survivability analysis assesses the enterprise network robustness relative to network component failure. The changes made to the original enterprise network model may have changed the enterprise network survivability characteristics. Survivability corresponds to the network's ability to support the network traffic when one or more nodes and/or links, defined for the enterprise network, fail. In general, the process consists of simulating network component failure and assessing the percentage of simulated network conversation failures. The extent of this process is defined by the amount of changes that have been made to the model.

7.3.2.5 Cost

Depending on the extent of the changes that are required within the enterprise network, cost may be a factor to consider in the optimization process. Increasing capacity to satisfy the requirements is an obvious solution. However, there is a price to pay for the additional bandwidth. One may want to consider the recurring cost of additional bandwidth as well as additional network nodes within the Alternative Design Process.

7.3.2.6 Expansion

While this process strives to achieve an optimal design alternative for the particular changes required, it short-sighted not to consider needs of future enterprise network growth. The growth addressed here is the slow, subtle type that inevitably occurs for various reasons (for example, World Wide Web applications). The Baseline Definition Process history can help define utilization trends in the enterprise network and provide guidance for ascertaining additional required bandwidth.

Major change requirements, such as the significant increase in users and the addition of new sites to support a particular application, are assumed to be addressed by the IT life cycle of the application and the invocation of a new GNAP cycle.

7.3.3 Implementation Guidelines

The proposed outcome of the iterative process, running the simulation and optimizing (fine-tuning) the enterprise network model, is an enterprise network alternative design meeting specified application requirements (for example, QoS). The process should provide enough information to the enterprise network operation process to implement the network changes. Depending on the GNAP objectives, the product set may vary. In most cases it includes:

- Topology of the enterprise network, particularly the changes related to the original GNAP objectives. This includes maps (geographical and/or logical) of the network, list of LANs, LAN and WAN links with associated sizing and headroom bandwidth when applicable, and node list with their characteristics.

- Performance information associated with the changes. The attributes include predicted response time, predicted link utilization, recurring cost estimate, and predicted survivability.

When new traffic profiles are generated by and used in this process for generating conversations, they will eventually be fed back to the NAITP (in the IT process) to be stored in the application database.

7.3.4 Alternative Design Process Overview

```
BEGIN
   Get the new baseline from the behavior analysis process
    If the baseline is not the entire original baseline + changes, then

    BEGIN
        Merge the extracted baseline + changes to original    baseline
        Execute validation
    END;

     While there are scenarios (what-if) to run, do
      BEGIN
           While the GNAP requirements and QoS are not met do
           begin
              Run the simulation
              Analyze the results
          begin
                     Routing analysis
                     Utilization analysis
                     Response time analysis
                     Survivability analysis
                     Cost analysis
                 end
              Change the model base on the finding of the analysis
           end
           Assess the need to increase bandwidth for growth purpose
       END

     Generate input to the network implementation process
           BEGIN
               Maps of the enterprise network modified to support the
               changes
               List of LANs
               LAN and WAN links with sizing information
               Network node list with associated characteristics
               Predicted response time information
               Predicted link utilization
               Costing information related to the change
               Predicted survivability information
               Traffic models forwarded to the NAITP
         end
 END.
```

8.0 Acronyms

CAM	Combined Administrative Management
DTS	Dedicated Transmission Service
FDDI	Fiber Distribute Data Interface
FTP	File Transfer Protocol
GNAP	Geographic Network Analysis Process
HTTP	Hyper Text Transfer Protocol
IGRP	Interior Gateway Routing Protocol
IP	Internet Protocol
IT	Information Technology
LAN	Local Area Network
MIB	Management Information Base
NAITP	Network Application Identification Tracking Process
NED	Network Engineering Division
NMS	Network Management System
NOC	Network Operation Center
OCIO	Office of the Chief Information Officer
OSPF	Open Shortest Path First
POP	Point of Presence
PVC	Permanent Virtual Circuit
QoS	Quality of Service
RIP	Routing Information Protocol
RMON	Remote Monitoring
RPM	Resource Planning Methodology
SLA	Service Level Agreement
SNA	System Network Architecture
SNMP	Simple Network Management Protocol
TEN	Telecommunications Enterprise Network
WAN	Wide Area Network

9.0 References

[1] USDA Information System Technology Architecture, Part III: Telecommunications Architecture, Revision 3.0, November 4, 1998.

[2] USDA Network Design Process, Issue 1.1, August 1997.

[3] Network Application Identification Tracking Process (NAITP), In progress.

[4] Clewett, A., Franklin, D., McCown, A. Network Resource Planning for SAP R/3, BAAN IV, and PeopleSoft (New York: MacGraw-Hill, 1998)

Appendix

This section provides general guidelines to establish Service Level Agreement and presented here for information purposes. The text was originally provided by *Northeast Consulting Resources* and extracted from *Network Computing* publication - November 1, 1998.

A Service Level Agreement (SLA) defines the responsibilities of both the IT service provider and the users. Typically, an SLA will include the following:

1. Definition of the service provided, the parties involved, and the effective dates of the agreement.

2. Specifications of the hours and days during which the service will be offered, including testing, maintenance and upgrades.

3. Specifications of the numbers and/or locations of users and/or hardware for which the service will be offered.

4. Explanation of problem-reporting procedures, including conditions of escalation to the next level of support. The explanation should include a definition of expected response time to a problem report.

5. Explanation of change-request procedures. This portion may include expected time for completing routine change requests.

6. Specification of target level of service quality, including:

    - Average availability, expressed as the average number of failures per service period and lowest availability

    - Average response time and highest response time

    - Average throughput

    - Explanations of how these metrics are calculated and how frequently they are reported.

7. Specifications of charges associated with the service. May be a flat rate or may be tied to different levels of service quality.

8. Specifications of user responsibilities under the SLA (user training, maintaining proper desktop configuration, not introducing extraneous software or circumventing change management procedures).

9. Description of procedures for resolving service-related disagreements.

10. Process for amending the SLA

Ideally, SLA's are defined as a particular service is being set up. This allows the hardware and software configurations to be designed to maximize the ability to meet the SLA.